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**SCIENTIFIC OPINION**

# Scientific Opinion on the welfare of cattle kept for beef production and the welfare in intensive calf farming systems[1]

**EFSA Panel on Animal Health and Welfare (AHAW)**[2, 3]

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## ABSTRACT

Information given in previous Opinions "Welfare of cattle kept for beef production" (SCAHAW, 2001) and "The risks of poor welfare in intensive calf farming systems" (EFSA, 2006) is updated and recent scientific evidence on the topics reviewed. Risks of poor welfare are identified using a structured analysis, and issues not identified in the SCAHAW (2001) beef Opinion, especially effects of housing and management on enteric and respiratory diseases are reviewed. The Opinion covers all systems of beef production, although the welfare of suckler cows or breeding bulls is not considered. The Chapter on beef cattle presents new evidence and recommendations in relation to heat and cold stress, mutilations and pain management, digestive disorders linked to high concentrate feeds and respiratory disorders linked to overstocking, inadequate ventilation, mixing of animals and failure of early diagnosis and treatment. Major welfare problems in cattle kept for beef production, as identified by risk assessment, were respiratory diseases linked to overstocking, inadequate ventilation, mixing of animals and failure of early diagnosis and treatment, digestive disorders linked to intensive concentrate feeding, lack of physically effective fibre in the diet, and behavioural disorders linked to inadequate floor space, and co-mingling in the feedlot. Major hazards for white veal calves were considered to be iron-deficiency anaemia, a direct consequence of dietary iron restriction, enteric diseases linked to high intakes of liquid feed and inadequate intake of physically effective fibre, discomfort and behavioural disorders linked to inadequate floors and floor space.



## KEY WORDS

Beef cattle welfare, welfare of calves in intensive farming systems, risk assessment, updates.

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## SUMMARY

Following a request from the European Commission, the Panel on Animal Health and Welfare (AHAW) was asked to deliver a Scientific Opinion on the welfare of cattle kept for beef production and of calves in intensive farming systems.

The European Commission is in the process of evaluating the European Union policy on animal welfare, taking account of socio-economic and trade issues. The overall aim is to improve the welfare of animals. To this end, the Commission requested EFSA to give an independent view on animal-based measures for the assessment of welfare in cattle, pigs and poultry. Before starting this work for beef cattle and calves, the Commission requested an update of scientific evidence relating to the welfare of cattle kept for beef production and calves in intensive farming systems; in particular, to consider the extent to which the conclusions and recommendations of two previous Scientific Opinions were still valid. These Opinions were the "Welfare of cattle kept for beef production" (SCAHAW, 2001) and "The risks of poor welfare in intensive calf farming systems" (EFSA, 2006).

The SCAHAW (2001) Opinion "The Welfare of Cattle kept for Beef Production" differed from EFSA Opinions, in that it did not include a formal animal welfare risk assessment. Over half the Opinion was a description of production systems, housing design and natural behaviour of cattle. Effects of housing, management and the environment on behaviour and some aspects of welfare were reviewed in detail. However, many factors with impact on welfare, such as breeding and genetics, feeding and feeding disorders, interactions between management, infectious disease and cattle welfare were reviewed only briefly or not at all. Where the SCAHAW (2001) Opinion was comprehensive (e.g. behaviour, mutilations), this current Opinion reviews only new evidence and only amends the conclusions and recommendations justified by this new evidence. Where the SCAHAW (2001) Opinion contains little or no evidence, it has been necessary to include references that precede 2001, and present new conclusions and recommendations. In this Opinion all systems for rearing cattle for beef production have been considered, ranging from intensive systems, where the animals are housed throughout life, to semi-extensive systems, in which animals are finished at pasture. The welfare of suckler cows and breeding bulls was not considered by SCAHAW (2001) and, to comply with the scope of the mandate, it is not considered here either. However, it is recommended that it be considered in a future mandate.

The Chapter on the welfare of calves in intensive farming systems adopts a similar approach to the previous Opinion (EFSA, 2006). It updates the review of scientific evidence and the approach to risk assessment, since developed and consolidated in the EFSA Scientific Opinion (2012) "Guidance on Risk Assessment in Animal Welfare". The production systems under consideration relate to calves, from the dairy herd reared for white veal, pink veal or prior to entry into beef production units. The welfare of unwanted "bobby" calves killed shortly after birth was not considered in the EFSA (2006) Scientific Opinion on the welfare of calves in intensive systems and, once again, to comply with the scope of the mandate it is not considered here. However, it is recommended that it be considered in a future mandate.

The impact of heat and cold stress on the welfare of beef cattle was not considered in SCAHAW (2001), so it has been reviewed in detail. Beef cattle can tolerate and adapt to a wide range of air temperatures, and metabolic heat production increases with increasing feed intake. Thus, animals on the highest rations are least sensitive to cold and most sensitive to heat. Cold stress can be reduced by provision of appropriate shelter and a dry lying area. Therefore, it is recommended that beef cattle confined in houses or open feedlots should be provided with structures and facilities to reduce the effects of factors contributing to thermal stress such as excess air movement, precipitation, relative humidity and solar load. Provided that these are effective there is no need to make provision for the control of air temperature.

Beef cattle kept on slatted floors have a higher incidence of injuries than animals on straw or sloped, partially straw-bedded areas. Partial rubberisation or rubber mats on concrete floors, especially for

lying areas, reduces the prevalence of lesions to claws and joints. However, wherever possible, cattle housed on slatted concrete floors should have access to a bedded area. Particular attention to the type of slats should be given to avoid slipperiness.

New evidence suggests that castration by rubber ring alone is less painful than a combination of Burdizzo and rubber rings. Rubber ring castration should be used in animals only under the age of 2 months and the scrotum cut after 8-9 days of ring application. Immunocastration has been shown to reduce aggressive and sexual behaviour in bulls. Surgical castration may lead to complications such as haemorrhage, infection, severe inflammation and tetanus. Approximately 35 % of beef cattle in Europe are disbudded and 15 % are dehorned by amputation. Nevertheless, disbudding or dehorning with sedation only, results in severe stress and pain. Therefore, cattle at any age should always be provided with local or regional anaesthesia at the time of surgical mutilations and systemic analgesia for two days or so thereafter.

Genomics and related technologies offer new opportunities for utilising existing genetic variability to improve several important welfare related traits, such as disease resistance, fertility, heat tolerance, and temperament. Selection tools have been successfully developed to identify carriers of deleterious genes and to control many genetic and environmentally-induced diseases. In the category of pathogen-associated disease, rapid progress is being made toward implementation of data collection, identification of DNA markers and development of tests that can be used in marker-assisted selection. Therefore, it is recommended that further research aimed at developing tools needed for implementation of marker-assisted selection to improve general resistance to disease.

Beef cattle fed intensively on high grain rations (< 15 % physically effective fibre) are at high risk of digestive disorders, especially sub-acute ruminal acidosis (SARA). Cattle that experience repeated episodes of SARA are at risk of rumen parakeratosis, liver abscesses and laminitis. Measures for the control of SARA include the feeding of buffers, drugs to stimulate salivation, and antibiotics (not permitted in the EU). Rations for finishing cattle should include at least 15 % physically effective fibre to reduce the risk of bloat, SARA and its sequelae. Feed supplements for the control of SARA should be restricted to those that stabilise rumen pH through natural buffering.

Most beef cattle diseases have a multi-factorial aetiology. In addition to pathogens and animal-related conditions, other contributing factors include environmental stressors that disturb homeostasis in the animal. These diseases can become chronic when infected animals are not detected and treated early. Chronic pneumonia results in very poor welfare with pain, asphyxiation and ill-thrift. Calves showing severe respiratory distress after multiple treatments should be killed on the farm. To promote effective control of multifactorial infectious diseases, cattle should be kept in environments that minimise physiological and emotional stress.

When calves are reared for veal production it is essential to provide solid feed containing adequate amounts of physically effective fibre in order to promote the development of a healthy and functional rumen, stimulate normal rumination behaviour and prevent abnormal oral behaviours. The conclusions of the EFSA (2006) Opinion concerning the iron requirement and clinical anaemia in calves reared for white veal are largely supported by new research. However, clinical signs of iron-deficiency anaemia, including suppression of normal behaviour, may already occur prior to an actual decrease of blood haemoglobin levels. In white veal calves oral supplementation with iron may improve milk intake and digestion in animals exhibiting normal haemoglobin levels. Other clinical and biochemical measures in addition to blood haemoglobin levels should be included as indicators of anaemia in order to safeguard the welfare of veal calves restricted in their dietary iron supply. However, this topic requires further research.

A reduction of the lying space allowance from 1.25 $m^2$ to 0.75 $m^2$ per animal for calves with a live weight up to 100 kg and a reduction from 1.50 $m^2$ to 1.00 $m^2$ per animal for calves with a live weight up to 150 kg decreased the occurrence of synchronous resting and reduced the opportunity to lie in a relaxed recumbent posture. Addition of an environmentally-enriched post-feeding area to an automatic milk-feeding system can significantly reduce cross-sucking in group-housed calves reared for veal. More research should be focused on pen design to improve calf comfort and achieve environmental enrichment that improves welfare. There is little evidence that floor type has an effect on the health of veal calves. However, the prevalence of bursal swelling in the knee was significantly higher in veal calves housed on concrete (approximately 17 %) than that in calves housed either on wooden slats (approximately 7 %) or on rubber or straw (< 1 %). However, provision of small amounts of straw or rubber mats for veal calves on wooden slats can result in discomfort from floors that are wet and dirty, unless the bedding is well managed.

Calves that do not get good quality colostrum after birth are more susceptible to endemic enteric and respiratory diseases. Calves from dairy farms must get an adequate quantity of colostrum at the most appropriate time. Environmental factors predisposing to respiratory disease were lack of ventilation, high animal density, extreme temperatures, high relative humidity and ammonia concentration. Ventilation should be regulated in order to keep ammonia concentrations as low as possible without creating draughts at the calf level. Group-housing of calves resulted in better welfare for this social species, except when there was significant enteric or respiratory infectious disease. In order to minimise the risk of poor welfare, calves should be managed so as to minimise exposure to enteric and respiratory infection. When there is a significant risk of cross-infection, it may be necessary to prevent direct contact between calves, but retain visual contact, during the first weeks of life by keeping them in individual pens or hutches.

Prevention of common calf diseases in the first 6 months of life, such as diarrhoea and the bovine respiratory syndrome, requires a systematic approach by improving management and housing conditions, specifically the preparation of the cow, hygiene of the calving environment, including dry clean bedding and high air quality, immediate supply with maternal antibodies, putting calves from different sources into different air-spaces, and no mixing with older animals, as well as careful attention and a rapid response to any sign indicating disease. Identifying sick animals in the early stages of disease is a crucial element for therapeutic success.

The hazard analysis identified the most serious risks to beef cattle and calves on the basis of magnitude and probability of adverse effect. The hazard analysis for beef cattle identified three major categories of welfare problem attributable to risks associated with housing and management:

- Respiratory diseases: linked to overstocking, inadequate ventilation, and mixing of animals, as well as failure of early diagnosis and treatment.

- Digestive disorders: linked to intensive concentrate feeding, lack of physically effective fibre in the diet.

- Behavioural disorders: linked to inadequate floor space, co-mingling in the feedlot and intensive concentrates.

The main welfare problems for intensively reared calves attributable to risks associated with housing and management were:

- Iron deficiency anaemia: a direct consequence of dietary iron restriction used to produce white meat.

- Digestive and respiratory disorders: linked to high intakes of liquid feed and inadequate intake of physically effective fibre, and cross-infection resulting from mixing of calves from multiple sources.

- Discomfort and disturbed resting behaviour: linked to inadequate floors and floor space.

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## BACKGROUND AS PROVIDED BY THE EUROPEAN COMMISSION

In 2001, the former Scientific Committee on Animal Health and Animal Welfare issued a Scientific Opinion on the welfare of cattle kept for beef production. The Scientific Opinion was adopted on the 25th of April 2001[4].

In 2006, the Commission requested EFSA to issue a Scientific Opinion on animal health and welfare aspects of intensive calf farming systems and their ability to comply with the requirements of the well-being of calves from the pathological, zootechnical, physiological and behavioural points of view. The Scientific Opinion was adopted on the 24th of May 2006[5].

The Commission is in the process of evaluating the European Union policy on animal welfare taking account of socio-economic and trade issues. The general principle is to assess the best option to orient the European Union legislation towards an animal-based approach. The overall aim is to improve the welfare of animals. In order to do this, the Commission is in the process to request EFSA to give an independent view on the animal based welfare measures for cattle, pigs and poultry, such as described by the Welfare Quality® project's assessment protocols. However, before starting this work for cattle and calves, the Commission would need an update of the recommendations of the above quoted Scientific Opinions.

## TERMS OF REFERENCE AS PROVIDED BY THE EUROPEN COMMISSION

The Commission therefore considers it opportune to request EFSA to update the scientific knowledge on the welfare of cattle kept for beef production and the welfare in intensive calf farming systems, in particular to consider if the conclusions and recommendations of the two previous Scientific Opinions are still valid:

- Scientific Opinion on the “Welfare of cattle kept for beef production”. (Scientific Committee in Animal Health and Animal Welfare, adopted on 25th of April 2001).

- Scientific Opinion on “The risks of poor welfare in intensive calf farming systems” (EFSA-Q-2005-014).

The update should focus on the animal categories and farming systems of the above referred Opinions.

[4] http://ec.europa.eu/food/fs/sc/scah/out54_en.pdf
[5] http://www.efsa.europa.eu/en/efsajournal/doc/366.pdf

## ASSESSMENT

## 1. General introduction

The European Commission mandate was to update scientific knowledge on the welfare of cattle kept for beef production and the welfare of calves in intensive farming systems and to consider whether the conclusions and recommendations of previous beef (SCAHAW, 2001) and calf (EFSA, 2006) Scientific Opinions were still valid.

The SCAHAW (2001) Opinion on “The Welfare of Cattle kept for Beef Production” differed from EFSA Opinions because it did not include a formal animal welfare risk assessment. Over half the Opinion was devoted to a description of production systems, housing design and natural behaviour of cattle. Two sections dealt with effects of housing and management on cattle welfare. Chapter 6, effects of housing, provided a detailed review of the physical effects of space and floor type on behaviour, pathology and production but there was little information on welfare problems associated with heat and cold exposure. Chapter 7, effects of management, reviewed mutilations (e.g. disbudding, dehorning, and castration), grouping of animals and human-animal interactions in detail. In addition, since the section on genetics was written, modern genomic approaches (e.g. marker-assisted selection) have been developed. The section on feeding did not incorporate much of the scientific knowledge, available at the time or later, on feeding-related diseases and disorders in beef cattle. Interactions between management, infectious disease and cattle welfare were described only briefly.

Where the SCAHAW (2001) Opinion was comprehensive (e.g. behaviour, mutilations), this current Opinion reviews only new evidence and only amends the conclusions and recommendations where justified by this new evidence. Where the SCAHAW (2001) Opinion contained little or no evidence (e.g. thermal stresses, genomics, feeding-related disorders, management of infectious diseases), it has been necessary to include references, some of which precede 2001.

The welfare of suckler cows and breeding bulls was not considered by SCAHAW (2001) and, to comply with the scope of the mandate, it is not considered here either. However, it is recommended that it be considered in a future mandate.

The Terms of Reference for the EFSA Scientific Opinion on “The risks of poor welfare in intensive calf systems” (EFSA, 2006) were to update the findings of the Scientific Veterinary Committee (Animal Welfare Section) report on the welfare of calves (SVC, 1995) in light of more recent data on this issue, to conduct a structured risk assessment and to identify major and minor risks for poor animal health and welfare. The present Opinion updates the approach to risk assessment first used in the 2006 Scientific Opinion, which has since been developed and consolidated in the EFSA Scientific Opinion “Guidance on Risk Assessment in Animal Welfare” (EFSA, 2012). In essence, this approach defines, categorises and (where possible) quantifies environmental and management factors contributing to an ***Input Scenario*** that acts upon a ***Target Population*** (e.g. intensively-reared calves) to produce ***Welfare Consequences***, which are assessed from a series of welfare measures. Wherever practical, these are animal-based.

The SCAHAW Opinion (2001) did not contain a risk assessment, therefore tables of risk assessment for growing cattle in beef production systems are presented here.

The welfare of unwanted “bobby” calves killed shortly after birth (see Table 2) was not considered in the EFSA (2006) Scientific Opinion on the welfare of calves in intensive systems and, to comply with the scope of the mandate, it is not considered here either. However, it is recommended that it be considered in a future mandate.

To follow the mandate, the structure of the previous Opinions was maintained. In brief, the approach taken to update it was as follows.

For each section, the new information was evaluated with respect to the conclusions and recommendations of the Opinion, and:

- when, based on the new information, it was necessary to append the previous conclusion and/or add a new one, the section was labelled as "*New information is added to the text of section XX of the previous Opinion*";
- when the new information did not critically affect the previous conclusions, the section was labelled as "*No critical new information to be added to section XX of the previous Opinion";*
- when new information relevant to the welfare belonged to a topic outside those covered in the previous Opinion, a new section was created and labelled as "*New section*".

## 2. Methods

### 2.1. Literature search

A search of the scientific literature published, after 2001 for beef cattle and after 2005 for calves, was carried out using generic key words (i.e. behaviour, climate, housing, stress, welfare, disease, feeding, genetics, health and management). As a result, 101,627 new references since 2001 were found for cattle and 30,979 since 2005 new references were found for calves. References were divided according to these generic search key words. Since the working group of experts found some difficulties in searching relevant references according to this generic division, additional work was performed by splitting the references according to specific keywords relevant to each section of the Opinion (i.e. antimicrobial, enteric disease, space allowance, branding, etc.). Only relevant references according to these specific key words were considered, and duplicated references were deleted. This process resulted in the provision to the working group of 29,064 relevant references for beef cattle and 12,486 for calves. In this Scientific Opinion, references prior to 2001 and 2005, respectively, were only included if the topic, or the significant reference, were not included in the earlier Opinions.

### 2.2. Risk assessment

The risk assessment for this mandate followed the methodologies in the Guidance on Risk Assessment for Animal Welfare (EFSA, 2012), and the approach is detailed in Appendix 2. The specific modifications made to the Guidance and used in this Opinion relate to the expert elicitation method and to the presentation of the risk characterisation estimate. A structured expert elicitation method was used to score the magnitude of the effects and their duration, and the exposure and the probability of occurrence at the individual level. In a first scoring round, the experts were asked to score individually each of the parameters associated with the risk factor for each population, based on current scientific knowledge and published data. In a second round of classification, the experts were asked individually to reconsider their scores, taking account of the scores of the other experts, but the identity of the experts was kept anonymous. In a final scoring round, those factors for which the scores were not consensual were discussed among the experts in order to clarify the formulation factor, and a consensual score was attributed to the factor.

In this report, the risk characterisation was not made via a single quantitative risk indicator, but instead by presenting both a qualitative estimation of magnitude for the adverse effect resulting from the exposure to a factor and a quantitative estimate of the probability of occurrence of that adverse effect in the target population. This approach avoids major assumptions about the linearity of the association between intensity and duration for estimating the magnitude, and provides stakeholders and interested parties with a better understanding of the major welfare problems.

To identify the major hazards for this population, the criterion set represented those hazards with a "Very High" magnitude and with at least a 2 % probability of occurrence and those with a "High" magnitude and at least 10 % probability of occurrence.

# 3. BEEF CATTLE

## 3.1. Introduction

Since the previous beef and calf Opinions, which considered various production systems, were produced five years apart and differed greatly in approach, as well as presentation of conclusions and recommendations, the new information has been presented in two separate Chapters. This Scientific Opinion considers systems of beef production (i.e. from cattle aged more than 6 months at the time of slaughter).

The SCAHAW (2001) Opinion "The Welfare of Cattle kept for Beef Production" was presented under the following broad headings:

- Definition and assessment of animal welfare
- Production systems and state of the industry
- Housing systems
- Behaviour of cattle
- Effects of housing on cattle welfare
- Effects of management on cattle welfare
- Conclusions and recommendations

The SCAHAW Opinion Provides a comprehensive review of the scientific evidence on these topics up to 2000. Much of the information in the chapters on production and housing systems involved the description of conventional systems and need not be repeated in this current Opinion. The 2001 Opinion considered only the welfare of growing animals in the slaughter generation and did not consider the welfare of cows and bulls used for breeding. Although approximately two thirds of calves reared for beef are born to cows from the dairy herd, their welfare was not considered by SCAHAW (2001) or any subsequent EFSA Opinions. The welfare of suckler cows and bulls was also not considered by SCAHAW (2001) and, for reasons of consistency, these animal categories were not considered here either.

The three sections dealing with direct risks to welfare are:

- Effects of environment and housing on cattle welfare
- Effects of nutrition on cattle welfare
- Effects of management on cattle welfare

The first of these sections reflects the need to consider the impact of both indoor and outdoor environments on the welfare of beef cattle. The section on effects of nutrition is consistent with the EFSA Opinion on Welfare in Intensive Calf Systems (2006), and gives greater emphasis to the impact of nutrition on welfare than appeared in the SCAHAW Opinion (2001). An important difference between this Opinion and SCAHAW Opinion (2001) has been to adopt EFSA policy in order to link the presentation of conclusions and recommendations.

### 3.2. State of the industry

Beef production systems in the European Union differ with regard to the method of feeding, the housing system and the age and weight at which animals are slaughtered. The two main sources of calves for beef production are: (i) beef suckler (or cow/calf) herds where the primary function of the adult cows is to produce one beef calf per annum, and (ii) dairy farms where the production of calves destined for beef is secondary to the main enterprise of milk production and the production of replacement heifers. At the time of the SCAHAW Opinion (2001), there were approximately 28 million dairy cows and 13 million suckler beef cows in the EU. In subsequent years, the numbers have decreased to 23.1 million dairy cows (Eurostat, online) and 12.4 million suckler cows (Hocquette and Chatelliert, 2011), respectively. It is interesting to note that, although they have both decreased, the ratio of dairy:suckler cows has remained relatively constant at about 2:1. In 2010, the total population of calves for slaughter was approximately 5.38 million (Table 1), and this Scientific Opinion refers mostly to this population.

**Table 1:** Data on beef and calf production in the European Union Member States (year 2010) - *Source: Eurostat, online.*

| Country | Total population of cattle (1,000 animals) | Total population of dairy cows (1,000 animals) | Total population of calves for slaughter (1,000 animals) | Total population of other calves (1,000 animals) | Slaughtered cattle (1,000 animals) |
|---|---|---|---|---|---|
| **Belgium** | 2,509.5 | 517.7 | 170.8 | 514.8 | 487.878 |
| **Bulgaria** | 544.5 | 308.2 | 57.2 | 82.6 | 17.702 |
| **Czech Republic** | 1,319.4 | 375.4 | 25.1 | 363.1 | 244.862 |
| **Denmark** | 1,630.0 | 573.0 | 281 | 272.0 | 362.500 |
| **Germany** | 12,706.2 | 4,181.7 | 211.0 | 3,656.6 | 3,398.547 |
| **Estonia** | 236.3 | 96.5 | 3.1 | 59.6 | 35.592 |
| **Ireland** | 5,917.7 | 1,027.0 | 0 | 1,694.6 | 1,709.920 |
| **Greece** | 679.0 (p) | 144.0 (p) | 71.0 (p) | 111.0 (p) | 189.535 |
| **Spain** | 6,075.1 | 845.3 | 1,529.9 | 591.0 | 1,432.374 |
| **France** | 19,654.0 | 3,718.0 | 844.0 | 4,786.0 | 3,491.683 |
| **Italy** | 5,832.5 | 1,746.1 | 507.5 | 1,228.7 | 2,929.793 |
| **Cyprus** | 54.7 | 23.4 | 9.4 | 10.7 | 10.324 |
| **Latvia** | 379.5 | 164.1 | 51.2 | 54.4 | 77.065 |
| **Lithuania** | 748.0 | 359.8 | 65.2 | 115.0 | 168.205 |
| **Luxembourg** | 194.0 | 46.0 | 4.3 | 47.3 | 25.359 |
| **Hungary** | 686.0 | 239.0 | 52.0 | 118.0 | 99.704 |
| **Malta** | 15.0 | 6.4 | 0 | 4.4 | 5.503 |
| **Netherlands** | 3,960.0 | 1,518.0 | 921.0 | 657.0 | 538.353 |
| **Austria** | 2,013.3 | 532.7 | 170.3 | 463.8 | 624.859 |
| **Poland** | 5,561.7 | 2,529.4 | 90.7 | 1,295.9 | 1,311.854 |
| **Portugal** | 1,502.8 | 243.2 | 122.4 | 314.7 | 273.191 |
| **Romania** | 2,001.1 | 1,178.6 | 134.0 | 286.3 | 104.288 |
| **Slovenia** | 470.2 | 109.5 | 24.8 | 122.0 | 100.672 |
| **Slovakia** | 467.1 | 159.3 | 18.0 | 113.9 | 49.547 |
| **Finland** | 908.9 | 284.3 | 3.6 | 298.9 | 262.003 |
| **Sweden** | 1,474.5 | 348.6 | 21.3 | 459.1 | 424.506 |
| **United Kingdom** | 9,896.0 | 1,847.0 | 0 | 2,861.0 | 2,698.245 |
| **EU - 27** | 87,437 (p) | 23,122.2 (p) | 5,388.8 (p) | 20,582.4 (p) | 21,074.064 |

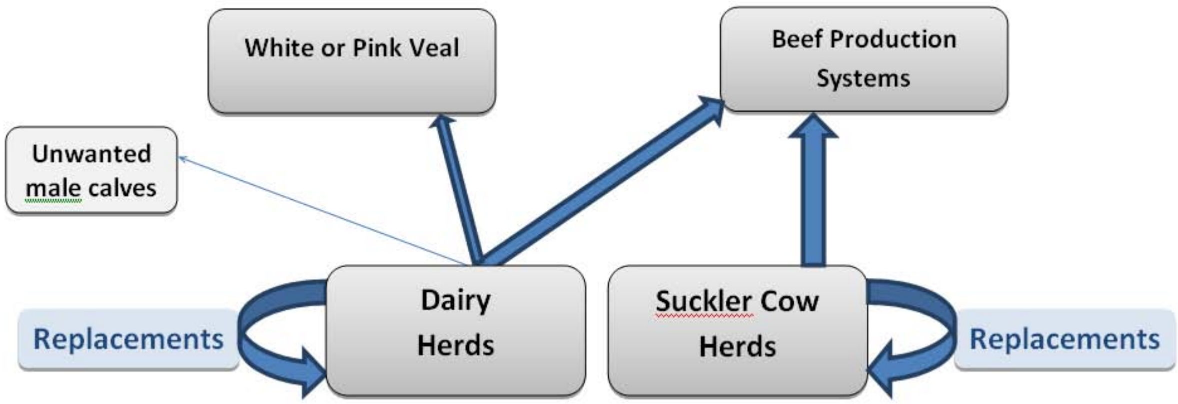
*(p): provisional value.*

Beef fattening systems may be divided into two main categories: intensive systems, where the calves are reared indoors, and grass-based systems, usually involving winter accommodation. The diversity of beef fattening systems in the EU is influenced by the type of diets (largely related to the climatic environments) and by the different cattle breeds. These breeds may be dairy (primary output milk), dual purpose (producing milk and beef) or beef (primary output beef). The EU dairy herd is dominated by the Friesian/Holstein breed. In contrast, the EU beef herd is very diverse. A wide range of breeds, varying greatly in phenotype from the relatively small, early maturing Hereford to the large, late maturing Charolais, have been selected to meet the different climatic and nutritional circumstances of the pastoral regions of Europe. When there is greater uniformity of environment and nutrition, as in intensive fattening systems, there is less need for this genetic diversity. However, breeding herds of suckler cows are likely to be kept out of doors for much or all of the year and are expected to subsist on pasture and forage with minimal supplements of purchased concentrates. The optimal strategy for a suckler herd is based on divergent selection for relatively small, hardy cows with low maintenance costs (e.g. Hereford x Aberdeen Angus) and large, fast growing sires with excellent beef conformation (e.g. Charolais; Webster, 1989). The husbandry of suckler cows at pasture generally results in good welfare but there can be problems (e.g. undernutrition, mineral deficiencies, and climatic stress). As the mandate from the Commission only requested an update of the previous reports, these animal categories have not been addressed in this Opinion, since they were not considered in the SCAHAW (2001) and EFSA (2006) Opinions. However, it is considered necessary to review the welfare of dairy calves raised for beef, and of suckler cows and breeding bulls in the near future.

### 3.2.1. Beef from dairy herds

A general flow of calves from dairy herds and suckler cow herds into various meat production systems is shown in Figure 1. This opinion deals with calves raised for "White or Pink Veal" and calves from dairy herds going into various "Beef Production Systems". The other animal categories shown in Figure 1 are not covered in this Opinion.

**Figure 1:** Diagram showing the general flow of calves from dairy herds and suckler cow herds to intensive veal and beef production systems.




Dairy cows, predominantly of the Holstein/Friesian type, may be inseminated with semen from dairy-type bulls (e.g. Holstein/Friesian), in order to provide replacement heifers for the dairy herd, or with semen from beef-type bulls (e.g. Charolais, Limousin, Aberdeen, Angus) to provide crossbred male and female calves with suitable conformation for prime beef production. Male calves from dairy cows bred with dairy bulls (e.g. Holstein x Holstein) are inferior in conformation according to such measures as the muscle:bone ratio and killing-out percentage, and they are unsuited to rearing systems based primarily on pasture and forage. Depending on their breeding, conformation (and market value) at birth, most male calves from dairy herds will be reared for beef in intensive (housed) systems. Calves of extreme dairy type, with poor conformation may be reared for veal. Many calves destined for beef are separated from their mothers at 1 to 2 days of age and artificially reared on milk or milk replacer plus solid food for a 6 to 9 week period. They are then weaned off milk or milk replacer and as functional ruminants are thereafter dependent on a diet of solid food (i.e. forages, such as hay, straw, grass, silage) or forages plus concentrates. This early rearing stage will take place on the farm of origin or in specialist calf rearing units and these animals subsequently enter beef fattening systems. The fattening system will depend on the region, tradition, type of diet available and market outlet.

Approximately 68 % of all veal calves produced in the EU are fattened on predominantly liquid diets (Eurostat, online). The welfare of these calves is considered in the Chapter 4 on calves. A further significant proportion of dairy-type calves are considered unsuitable either for intensive beef or veal production by virtue of their conformation, or constraints on international trade (e.g. concerns relating to bovine tuberculosis in the UK), and are killed shortly after birth. These animals are not registered in farm records. Table 2 gives the numbers of female and male calves registered from dairy herds within the UK in 2009 (Compassion in World Farming, CIWF, online). For cows registered as British Friesians the ratio of males to females was 1.04, which is consistent with published evidence on the natural ratio of male:female births in cattle, and implies no difference in neonatal mortality between the sexes. For cows registered as Holstein/Friesian (i.e. herds with a significant proportion of genes from North American Holstein stock), the ratio was 0.79 implying that 25 % of male calves (1.04 - 0.79 x 100) died or were killed shortly after birth. For pure Holsteins, the ration was 0.61 and for the Channel Island breeds of extreme dairy type (Jersey and Guernsey) the ratio was 0.21, implying that 83 % of calves were killed as "unwanted" immediately or shortly after birth. The welfare issues associated with unwanted bull calves from dairy herds were not addressed in any of the previous Opinions and are not addressed here. However, they are of significant public concern and they should be urgently addressed.

**Table 2:** Registered births of female and male calves to cows in UK dairy herds in 2009 (CIWF, online).

| Breeds | Registered females | Registered males | Ratio |
|---|---|---|---|
| Holstein | 48.030 | 29.127 | 0.61 |
| Holstein x Friesian | 285.727 | 225.632 | 0.79 |
| British Friesian | 60.038 | 62.943 | 1.05 |
| Channel Island | 20.569 | 4.385 | 0.21 |

### 3.2.2. Beef from suckler cow herds

Suckler cow herds, in which calves remain with their dam at pasture until they are 5-9 months of age, constitute a very important farming sector in the grassland areas of Europe. Hocquette and Chattelliert (2011) also reported that there are approximately 12.4 million suckler cows within the EU. The three main areas of suckler (or cow-calf) farming are the extensive grasslands of northern Europe, including France, Ireland, UK (27 %), the Mediterranean areas of Italy, Spain, Greece and Portugal (20 %), and the mountain areas of France, Spain and Eastern Europe (16 %). On the majority of suckler cow units, weaned calves are transported to be finished on specialist fattening units. Some units (approximately 8 % of total beef production) rear their own calves to slaughter weight on high quality pasture.

### 3.2.3. Beef production systems

The following main beef production systems were described in detail in the SCAHAW Opinion (2001) and have not changed significantly since that time, as listed below:

- Bulls from the dairy herd housed and reared to 16 months on grass silage and concentrates;
- Bulls from the dairy herd housed and reared to 16 months on maize silage and concentrates;
- Bulls from the dairy herd housed and reared to 12 months principally on concentrates;
- Bulls from the suckler herd housed and reared to 16-18 months on grass silage and concentrates;
- Bulls from the suckler herd housed and reared to 16-18 months on maize silage and concentrates;
- Bulls from the suckler herd housed and reared to 12-15 months, principally on concentrates;

- Steers from the dairy herd reared to 24 months on pasture in summer, forage and concentrates during winter housing;

- Steers from the suckler herd reared to 24 months on pasture in summer, forage and concentrates during winter housing;

- Steers and heifers from dairy and suckler herds reared to slaughter at 2.5 years (or more) principally on pasture and conserved forage. Organic farming systems may be included within this group.

Feedlot systems (North American type) are those in which calves from suckler (cow/calf) herds are taken from pasture, typically as yearlings weighing 200-300 kg, and reared intensively to target slaughter weight in large open feedlots on a concentrate ration based principally on maize. The time spent on the feedlot will vary from approximately 150-250 days according to season and market demand.

***Conclusions***

1. In 2010, the total cattle population within the 27 EU Member States was approximately 87.4 million, of which 23.1 million were dairy cows.

2. In 2010, the total number of cattle slaughtered within the 27 EU Member States was approximately 21 million animals.

3. The welfare of breeding suckler cows and bulls and the welfare of unwanted male calves from the dairy herd are not considered in this Opinion but their welfare is an important subject for consideration.

***Recommendations***

1. The welfare of breeding suckler cows and bulls and the welfare of unwanted male calves from the dairy herd are of significant scientific and public concern and they should be urgently addressed.

## 3.3. Behaviour of cattle

Section 5. of SCAHAW (2001) described the behaviour of cattle as a basis from which to consider the impact of different management practices on behaviour. However, there is no critical new information to be added. Neverless, new evidence regarding the impact of feeding, housing, breeding and management on behaviour is reviewed in Section 3.5.3.

## 3.4. Effect of housing and environment on the welfare of the animals

New information is added to the text of Section 6 of the SCAHAW Opinion (2001).

In the European Union, beef production is characterised by a wide range of production systems that were outlined in Chapter 3 of the SCAHAW Opinion (2001). Regardless of the fattening system adopted some characteristics of the housing, such as microclimate, close confinement, space allowance and type of floor, can have a major impact on cattle welfare and will be discussed in detail. Other housing aspects, such as the space allowance at the feeding trough, will be considered briefly. In this review an attempt has been made to distinguish the effects of microclimate, confinement, space availability, type of floor and bedding material on fattening animals. In many studies, more than one of these factors varies and this makes the analysis difficult.

The microenvironment experienced by cattle in houses, on open feedlots or at pasture is determined by the microclimate (air temperature, air movement, humidity, solar radiation, precipitation), air quality (dust, including airborne microorganisms and endotoxins, and pollutant gases, such as ammonia) and the thermal and physical properties of the surfaces on which they rest (e.g. straw vs. concrete slats; Wathes et al., 1983). Ways of modifying the microenvironment include systems of natural and forced ventilation, provisions of shelter from wind and precipitation, shade from solar radiation and sprinklers to reduce heat load.

### 3.4.1. Thermoregulation, and cold and heat stress

New section.

#### 3.4.1.1. Heat exchanges

Thermal stress of animals in transport was reviewed by SCAHAW (1999) but SCAHAW 2001 contained no review of the complex factors affecting the heat exchange of cattle in different housed and outdoor systems. Therefore, this review makes reference to key papers published before, as well as after, 2001. Cattle are considered to be in a state of thermal comfort when the climatic conditions are such that they can, without substantial physiological effort, maintain a balance between heat production in metabolism and heat loss to the environment by conduction, convection, radiation and evaporation of moisture from the skin and respiratory tract. In the thermoneutral zone, the metabolic heat production of the animal is independent of ambient temperature. Maintenance of homeothermy within the thermoneutral zone involves behaviour (postural changes, huddling, seeking shade, etc.) accompanied by physiological regulation, at only a small cost, of sensible heat loss to the skin through regulation of peripheral blood flow, and evaporative water loss, largely from the skin. The lower critical temperature defines the point below which homeothermy cannot be maintained through regulation of heat loss and the animal has to elevate heat production (Webster 1974; Senft and Rittenhouse, 1985). The thermal demand of cold environments is determined by ambient air temperature and air movement, which determine convective heat loss, radiant heat exchanges, both ultraviolet and infrared, and the thermal conductivity of lying surfaces (Webster 1970a, 1974).

Work on the effects of high and low temperatures has focused mainly on the use of measures of body temperature and production. Few studies have assessed the strength of preference of cattle for different ambient temperatures. Heat stress occurs when air temperature is high so that sensible heat loss by convection and conduction is greatly reduced, and the cattle have difficulty maintaining, or fail to maintain, homeothermy through sweating and thermal panting (rapid shallow respiration). Conditions of high relative humidity increase heat load by reducing the efficiency of sweating and panting as a means of heat loss. The combined effects of temperature and humidity on cattle are conventionally expressed by the temperature (Ta, °C)/humidity (RH, %) index (THI; Kabuga, 1992; Davis et al., 2007), where:

$$THI = 0.8Ta + ((RH/100)\ (Ta-14.3)) + 46.4$$

The THI provides an effective indicator of heat load under confined conditions in houses or transport vehicles. Out of doors, it is necessary to modify the THI to include measures of air movement and solar radiation (Mader at al., 2006, 2010; Gaughan et al., 2008). Other authors that have sought to model the complex thermal interactions between cattle and the environment include Ames and Insley (1975), Ehrlemark and Sällvik (1996), Höppe (1999) and Keren and Olson (2006). The risk of heat stress for beef cattle in the Mediterranean basin has been estimated from the dynamics of the THI by Segnalini et al. (2011).

#### 3.4.1.2. Cold stress and adaptation to cold

The resistance of cattle to cold is influenced by metabolic heat production, which is itself a function of food intake, and two layers of insulation in series: internal insulation of the skin and subcutaneous fat, and external insulation provided by the hair coat and air trapped therein. Animals with a high food intake and thick fat cover are most resistant to cold stress, but most sensitive to heat stress. Cattle exposed to cold conditions during the winter increase external insulation by increasing the coat depth. The thermal insulation of the coat decreases with increasing air movement and is seriously compromised when the coat is wet.

Various calculations have been made to assess the lower critical temperature for cattle (e.g. Webster, 1970a, b; Young, 1981; Clark and McArthur, 1994). Table 3 summarises evidence from Webster (1970a) relating to changes in cold tolerance as measured by the lower critical temperature (LCT) resulting from these effects. Acclimatisation to cold winter conditions involving increased coat depth and changes in peripheral circulation associated with increased tolerance of low skin temperatures can, in extreme circumstances, reduce both the lower and upper limits of the thermoneutral zone by as much as 20 °C (Webster et al., 1970). The results shown in Table 3 were obtained under experimental conditions and may not cover all real life situations, and they may not apply to all animal categories (for instance, well adapted suckler cows may respond differently). These experiments were carried out in Western Canada during a winter when the mean ambient temperature in January-February was -28 °C. Table 3 also shows the extent to which heat loss, as assessed from the LCT, is affected by solar radiation (60 °C more cold tolerance), infra red radiation to the night sky (7 °C less cold tolerance), wind and wetting of the coat. Studies of how aversive low temperatures are to cattle have not been reported.

**Table 3:** Estimates of the lower critical temperature (LCT) of growing cattle (ca 300 kg) in different conditions (from Webster, 1970a).

| Outdoor conditions | LCT (°C) |
|---|---|
| Still air | |
| Autumn | +4 |
| Winter, dry, cloudy | -18 |
| Dry, 8h sun | -24 |
| Dry, 4h sun, clear night | -11 |
| Wind speed 4.5 m/sec | |
| Winter, dry | -8 |
| Wet coat | +2 |

Precipitation (rain) reduces the insulation capacity of the coat (Young et al., 1989) and cools the insulating air layer within the coat by evaporation (Eckert et al., 2000). Wind tunnel tests on reindeer fur have indicated the effect of wind and of various degrees of moisture, showing that moisture due to mist or light rain affected the insulating capacity marginally, whereas heavy rain dramatically decreased the insulating capacity of the fur through evaporation and direct reduction in insulation (Hillman et al., 1989; Cuyler and Øritsland, 2004; Jiang et al., 2005).

The ability of cattle to adapt to cold depends on how long the exposure to cold has lasted. Adaption to cold does not occur if exposure is too short or if it is intermittent (Kennedy et al., 2005). It seems that exposure should be for at least a week in order to start the adaption process (Christopherson and Young, 1986). The thyroid gland increases its production of hormones when the animal has been exposed long enough (Westra and Christopherson, 1976; Young, 1981). If feed is available, the animal increases feed intake in order to meet its greater energy demand. Behavioural adaptations to cold have also been found since beef cows were shown to graze more frequently than inexperienced cows in areas that were protected from weather (Beaver and Olson, 1997). Graunke et al. (2011) were able to demonstrate that cattle adjusted their behaviour to both Wind Chill Temperature (WCT) and precipitation in that they were able to find warmer microclimates and used conspecifics as protection. Estimates of the overall effects of severe winter weather on the thermal exchanges and feed energy requirements of beef cattle have been made by Webster (1970b), Keren and Olson (2006) and Wagner et al. (2008).

#### 3.4.1.3. Effects of cold on young calves

Calves are born with approximately 1 °C higher rectal temperature than the adult animal but this temperature decreases within the first six hours to normal values (Thompson and Clough, 1970). The cause seems to be the loss of heat from the moist fur. It has been shown that when a calf is subjected to cold, the absorption of immunoglobulin from the milk is reduced and hence resistance to infections is reduced (Olson et al., 1980, 1981b). Newborn calves are very tolerant in cold in dry conditions without wind, provided that they have a dry lying area (Radostits et al., 1999). For a newborn calf of 35 kg with a coat thickness of 1.2 cm the LCT in still air has been estimated at 9 °C, falling to 0 °C by 8 weeks of age (Webster, 1976). Calves kept out of doors in sheltered hutches with dry straw being added weekly have been shown to exhibit good health and normal growth at temperatures down to -30 °C provided that the lying area is dry (Rawson et al., 1988, 1989a, b). Moreover, the risks of infectious enteric and respiratory disease are reduced compared to calves kept indoors (Gutzwiller and Morel, 2003).

Studies of newborn calves of the Holstein breed, kept on straw and wood shavings in huts at +17 °C and in climate chambers where the temperature varied between -8 °C and -20 °C and between -18 °C and -30 °C showed that the calves in the two latter groups developed subcutaneous oedema, whereas the animals exposed to cold lost substantial portions of their fat deposits around the kidneys, indicating that metabolism of the brown fat was initiated (Rawson et al., 1989a). Similar studies in climate chambers at +1 °C and +4 °C of Holstein and Angus calves which had water poured on them gave similar resuts (Olson et al., 1980, 1981a; Carstens, 1994).

Injuries as a result of frost may affect calves that lack dry lying areas and protection against cold, wind and precipitation. Vasoconstriction in the ears was shown already in 12 day-old calves at + 19°C to +22 °C and in 76 day-old calves at +10 °C to +18 °C, with the lower values being for Friesian calves and the higher values for Jersey calves (Holmes, 1970).

Hereford heifers, kept in insulated pens, uninsulated pens and outdoors with a shelter from rain under cold Nordic conditions (minimum temperature -35 °C) did not show any harmful effects in terms of muscle injuries, significant stress or increased occurrence of disease in any of the treatments (Manninen et al., 2007). The authors concluded that replacement beef heifers on a restricted feeding scheme can be overwintered outdoors under such conditions, although the outdoor winter housing facilities must protect the animals from becoming wet and dirty where rain shelter and sufficient bedding material are important factors.

#### 3.4.1.4. Heat stress and adaptation to heat

The thermoneutral heat production of beef cattle ranges from about 100 W/m$^2$ at maintenance to about 160 W/m$^2$ when consuming a production ration *ad libitum* (Webster, 1974). As ambient temperature approaches deep body temperature, the proportion of this heat that can be dissipated by convection, conduction and radiation progressively decreases and the animal has to increase evaporative heat loss by sweating and thermal panting. *Bos taurus* has less capacity to sweat than *Bos indicus* and hybrids between the species (Beatty et al., 2006). Moreover, the evaporation rate of sweat is greater in animals with thinner, sleeker hair coats than thick rough coats. Differences in coat type are affected by genotype, and by seasonal environmental factors (Webster, 1974). Olson et al. (2003) have identified a major gene influencing hair length and heat tolerance in *Bos taurus* cattle. Dark coats absorb more heat than light coats when exposed to UV solar radiation. However, the colour of the coat has no effect on IR radiation exchanges (i.e. indoors). The optimal coat/skin type best suited to high temperature and high solar radiation load is sleek white hair over a black skin, (e.g. Fulani cattle) because the hair reflects a high proportion of solar radiation, and the black skin effectively radiates outwards much of what actually penetrates the hair coat (Cena and Monteith, 1975).

The minimal respiration rate of cattle in cool and cold environments is approximately 20/min. With increasing heat stress, respiration rates may increase to rates in excess of 100/min. In these circumstances, the animals are likely to show elevated rectal temperatures. Prolonged thermal panting leads to dehydration and alkalosis. In cases of extreme heat stress, shallow, nasal thermal panting may give way to mouth breathing. This is an indication of thermoregulatory failure and will lead to death unless the intensity of the heat load is removed.

For cattle in houses (or transport vehicles), the heat load may be assessed using the temperature/humidity index (THI). THI values over 78 are considered excessive if prolonged for more than 4 hours (Brown-Brandl et al., 2003). Increased air movement (natural ventilation or fans) increases convective heat loss, provided that ambient temperature (Ta) is lower than skin temperature (Ts). When Ta>Ts, increased convection increases heat load, and solar radiation can greatly increase heat load during daylight hours. One of the most effective ways to reduce heat load in open feedlots is to construct porous roofs that provide shade but permit hot air to escape. Heat stress can also be ameliorated by the provision of sprinklers (Mader et al., 2007) or sprinklers combined with forced ventilation (Berman, 2008). Sprinklers have a dual effect because they cool the skin of the cattle and the surrounding air through the latent heat of evaporation.

Cattle exposed to heat stress out of doors will seek shade in preference to sprinklers (Schütz et al., 2010). When closely confined in housing systems, cattle have little scope to reduce heat stress through selection of a more favourable microenvironment. Moreover, during prolonged periods of hot weather, the persistence of heat stress is likely to be greater indoors than on pasture or feedlot with access to shade. Nights are likely to be cooler out of doors, due to absence of UV solar radiation, increased IR radiation from the animals to the clear night sky and, usually, greater air movement (Webster, 1970a).

Adaptation to heat stress is also likely to involve a reduction in feed intake, in order to reduce metabolic heat production. Cattle may also modify their intake pattern by grazing during the night when the temperature is at its lowest, by increasing the number of meals and decreasing their length (Morand-Fehr and Doreau, 2001). The two best combined indicators of animal welfare and productivity in cattle exposed to hot environments are low respiration rate and the ability to sustain feed intake (Brown-Brandl et al., 2006). These indicate that the animals can effectively maintain homeothermy without significant physiological cost. Breeds that show high heat tolerance according to these measures include BT, BT x BI crosses and certain breeds of BT such as the Mertolenga (Pereira et al., 2007). Management of diet and feeding to ameliorate heat stress is considered in Section 3.5.3.6.

Other factors that influence the heat tolerance of beef cattle include temperament (calm animals are more heat tolerant) and previous experience of respiratory disease (reduced tolerance; Brown-Brandl et al., 2006). It should be noted that most of the evidence regarding adaptation to cold or heat stress is based on biological parameters, so it would also be interesting to evaluate animal preferences in relation to hot or cold conditions.

#### 3.4.1.5. Housing insulation

New information is added to the text of Section 6.1.1. of the SCAHAW Opinion (2001).

Insulation raises air temperature within the building relative to outside air. This brings several benefits in cold environments: a reduction in heat loss, a reduction in relative humidity within the building and an increase in natural ventilation via the stack effect. The reduction in relative humidity and increase in natural ventilation both contribute to a reduction in airborne microorganisms, thereby reducing the risks of respiratory diseases (Wathes et al., 1983).

In an epidemiological study of management- and housing-related risk factors of respiratory disorders in non-weaned French Charolais calves there was a higher risk in open-front barns or in open barns compared to closed ones (IRR 1.9 and 1.8 respectively for respiratory disorders; Assié et al., 2009).

Ammonia concentration (levels > 20 ppm) and other gases increase the risk of respiratory diseases by destroying the muco-ciliary epithelium and allowing access of bacteria and virus to the lower respiratory tract (Woolums et al., 2009).

***Conclusions***

1. Beef cattle can tolerate and adapt to a wide range of air temperatures.

2. Metabolic heat production increases with increasing feed intake. Thus animals on the highest rations are least sensitive to cold and most sensitive to heat. Cold stress can be reduced by provision of appropriate shelter and a dry lying area.

3. Adequate ventilation is crucial for cattle kept indoors especially in hot weather or when density is high. Adequate ventilation can be achieved either by forced ventilation or well designed natural ventilation systems.

***Recommendations***

1. Addition to Recommendation 8 of Section 6 of the SCAHAW Opinion (2001; see UR.3 in the Conclusions and Recommendations section): Beef cattle confined in houses or open feedlots should be provided with structures and facilities to reduce the effects of factors contributing to thermal stress, such as excess air movement, precipitation, relative humidity and solar load. Provided that these are effective there is no need to make provision for the control of air temperature.

2. The maximum ammonia concentration should be < 20 ppm.

### 3.4.2. Physical effects of the housing environment on the welfare of calves and beef cattle

#### 3.4.2.1. Effects of tethering

No critical new information to be added to Section 6.1.2. of the SCAHAW Opinion (2001).

### 3.4.3. Space allowance and pen design

No critical new information to be added to Section 6.2. of the SCAHAW Opinion (2001).

#### 3.4.3.1. Space allowance, pen design and behaviour

Some new information is added to the text of Section 6.2.1. of the SCAHAW Opinion (2001).

In a study on the effects of increased space allowance on finishing bulls in pens of 2.5, 3.0, 3.5 and 4.0 $m^2$/animal equipped with rubber coated slatted floors (Gygax et al., 2007) the bulls had more lying bouts per day (by a factor of 1.056/$m^2$), lay for longer periods (by a factor of 1.458/$m^2$) and changed their lying posture more often (+5.26 changes/$m^2$). In addition, they kept greater distances from other lying bulls, stepped less often on a lying bull (OR=0.341) and, with more space, the likelihood of animals being dirty was reduced.

#### 3.4.3.2. Space allowance and pen design and physiological parameters

No critical new information to be added to Section 6.2.2. of the SCAHAW Opinion (2001).

#### 3.4.3.3. Space allowance and pen design and pathology

No critical new information to be added to Section 6.2.3. of the SCAHAW Opinion (2001).

#### 3.4.3.4. Space allowance and pen design and production

No critical new information to be added to Section 6.2.4. of the SCAHAW Opinion (2001).

### 3.4.4. Type of floor and bedding material

No critical new information to be added to Section 6.3. of the SCAHAW Opinion (2001).

#### 3.4.4.1. Type of floor and behaviour

Data from the previous Opinion (Section 6.3.1. of SCAHAW, 2001) is supported by new research.

Mayer et al. (2007) and Absmanner et al. (2009) found a higher incidence of abnormal standing and lying movements in animals kept on slatted floors than in animals kept on straw.

Recent studies have confirmed that the use of modified "soft" slat surfaces, or partial rubberisation or rubber mats on concrete floors, especially the lying area, reduced abnormal standing up and lying down, and slips (Platz et al., 2007).

#### 3.4.4.2. Type of floor and physiological parameters

No critical new information to be added to Section 6.3.2. of the SCAHAW Opinion (2001).

#### 3.4.4.3. Type of floor and pathology

Data from the previous Opinion (Section 6.3.3. of SCAHAW, 2001) is supported by new research.

Lowe et al. (2001) showed that Continental-cross steers of 450 kg kept on straw were significantly cleaner than steers kept on perforated rubber mats or conventional slats.

The risk of respiratory disorders in non-weaned French Charolais calves was shown to increase by 1.9 and 1.6 (IRR) in part slope barns with straw/part scraped and part straw-bedded/part scraped barns, respectively, compared to completely straw-bedded barns (Assié et al., 2009).

#### 3.4.4.4. Type of floor and production

No critical new information to be added to Section 6.3.4. of the SCAHAW Opinion (2001).

***Conclusions***

1. Animals kept on slatted floors have a higher incidence of injuries and abnormal movements when standing up and lying down than animals on straw or sloped straw-bedded areas. Partial rubberisation or rubber mats on concrete floors, especially for lying areas, reduces the prevalence of lesions to claws and joints.

***Recommendations***

1. Wherever possible, cattle on slatted concrete should have access to a bedded area. Particular attention to the type of slats should be given to avoid slipperiness.

## 3.5. The effects of management on cattle welfare

### 3.5.1. Mutilations

New information is added to the text of Section 7.1. of the SCAHAW Opinion (2001).

#### 3.5.1.1. Introduction

It is important to emphasise that although it has been shown that very young animals feel pain, they may actually feel more pain than adults due to the immaturity of the nociceptive system (Fitzgerald, 1994). However, it should be noted that very little research has been carried out on the development of the nervous system in calves compared with other species. Furthermore, any mutilation will require animals to be restrained, which itself may cause some distress in addition to the pain of the mutilation. The stress response of cattle to the restraint necessary to carry out some mutilations (i.e. castration, disbudding/dehorning) may be lower in animals under 6 months of age compared to animals over 6 months of age simply due to their size. Overall, this could mean that when calves are mutilated at a young age they may suffer less overall pain and distress than old larger animals (King et al., 1991; Mellor et al., 1991; Robertson et al., 1994; Ting et al., 2005). Another issue is that the greater the volume of tissue damage, the more pain is caused. Thus, in older animals, castration will result in a more extensive area of tissue damage and so may cause more pain and a more prolonged recovery period (Bretschneider, 2005), although this is unlikely to be a linear relationship.

In most EU Member States, there was a reinforcement of using anaesthesia for most mutilations.

#### 3.5.1.2. Castration

New information is added to the text of Section 7.1.2. of the SCAHAW Opinion (2001).

The use of analgesia after castration differs with age and breed. In a survey it was shown that 6.9 % of beef calves and 18.7 % of dairy calves under 6 months of age and 19.9 % of beef calves and 33.2 % of dairy calves over 6 months of age, received some kind of anaesthesia at the time of castration (Hewson et al., 2007), but very few received post-operative analgesia.

Castration is carried out in cattle, according to Stafford and Mellor (2005), in order to:

- reduce aggressive and sexual behaviour,
- reduce the incidence of meat quality problems, particularly dark-cutting meat,
- encourage fattening,
- avoid unwanted pregnancies.

All castration methods, including Burdizzo clamp castration, ring or band castration, and surgical castration, cause intense acute pain and chronic pain that may last for some days and even up to 2 weeks (Marti et al., 2010). Pain is always severe independently of age, but the extent and dimension of tissue damage increases with the size of the animal. A review by Bretschneider (2005) indicated that weight loss increased greatly as the age of castration was increased and it was independent of the method used.

Another welfare issue that should be addressed is the magnitude and effect of the post-operative complications of each method. Dangerous consequences of castration with a clamp are necrosis and gangrene of the scrotum (Stafford and Mellor, 2005; Ewoldt, 2008), whereas surgical castration is associated with infection, tetanus and haemorrhage (Ewoldt, 2008).

Hormonal castration (immunocastration) is achieved by inducing antibody production against gonadotropin releasing hormone (GnRH), resulting in decreased production of endogenous hormones. This method has been shown to reduce aggressive and sexual behaviour of treated bulls (Price et al., 2003a). A vaccine that achieves this is commercially available in South America. Immunocastration largely avoids pain but will require the approval of the vaccine and injection of the product every 4 to 12 weeks (Rushen et al., 2008).

Several recent studies have assessed the efficacy of different analgesic protocols. Thüer et al. (2007) showed that a local anaesthetic injected into the spermatic cord and subcutaneously at the neck of the scrotum reduced acute pain during and immediately after calves were castrated by use of a castration clamp. Stilwell et al. (2008a) showed that epidural anaesthesia with lidocaine will reduce temporarily the pain caused by Burdizzo castration. Inflammation, pain-related behaviours and high levels of cortisol were still present at > 48 hours after clamp castration and were only abolished after the use of a long-acting NSAID (carprofen; Pang et al., 2006; Stilwell et al., 2008a).

Ring castration of Holstein calves performed at 3 months of age with local anaesthesia and analgesia decreased average daily gain and affected some behavioural traits during the first 14 days after castration (Marti et al., 2010). Coetzee et al. (2007) showed that i.v. sodium salicylate was effective in controlling pain in young calves castrated by ring but only for a few hours. Becker et al. (in press) showed more rapid healing time and shorter duration of chronic pain in animals in which the scrotum was cut under the rubber ring nine days after application, compared with those calves in which the scrotal tissue was left to drop off. This same study showed that the combination of Burdizzo and rubber ring, or using three rubber rings placed next to each other, led to more pain than traditional castration by one rubber ring. Surgical castration of calves (~300 kg) after low doses of xylazine plus ketamine showed less behavioural changes and lower serum cortisol concentrations during the first 60 minutes post-castration (Coetzee et al., 2010). Surgical castration through one incision for both testicles led to greater swelling and more signs of pain than when performed through one incision for each testicle because, with the former technique, adequate drainage was prevented (Stilwell, 2009).

#### 3.5.1.3. Spaying (ovariectomy)

Some new information is added to the text of Section 7.1.3. of the SCAHAW Opinion (2001).

Ovariectomy is performed on dairy cows to maintain lactation, or in beef heifers to avoid unwanted pregnancies, as these animals may have additional costs due to dystocia, prolapsed uterus and metritis (Pinner, 2006). However, at variance with the previous Opinion (SCAHAW, 2001), growth and carcass quality did not seem to be improved by spaying (Jeffery et al., 1997) unless hormone implants were used (Garber et al., 1990). Heifers are usually spayed by flank laparotomy or transvaginally by a method called the Willis Dropped Ovary Technique (WDOT).

Mortality may occur due to diffuse peritonitis or haemorrhage and chronic pain may be caused by localised and generalised peritonitis and adhesions. In Australia, WDOT is acknowledged as the least invasive transvaginal spaying method and is completed routinely without anaesthesia or postoperative analgesic medications (Jubb et al., 2003).

Spayed Brahman (*Bos indicus)* 2 year-old heifers showed pain-related behaviours and higher cortisol for 6 h post-procedure, and body weights and gains were significantly lower in the spayed compared with control heifers at days 21 and 42, independently of the method used, indicating comparable levels of pain and stress (McCosker et al., 2010; Petherick et al., 2011).

In contrast, haptoglobin concentrations were higher for four days in flank-operated animals, suggesting longer-lasting adverse effects on welfare from flank spaying than WDOT spaying (Petherick et al., 2011). Mortality was 1.5 % and 2.5 % for the WDOT and flank method, respectively. A total of 5 % of flank wounds had not healed after 42 days (McCosker et al., 2010). Another study reported that a few animals showed discomfort through mild stiffness and straining for the first 12 h and that some walked stiffly the next day (Habermehl, 1993).

Immunological spaying is possible and has been shown to result in similar growth rates to those in surgically spayed animals (Jeffery et al., 1997). Nevertheless, good management practices that prevent bulls from breeding with young heifers or those intended for fattening, may render spaying redundant.

#### 3.5.1.4. Tail-docking

Some new information is added to the text of Section 7.1.4. of the SCAHAW Opinion (2001).

The behaviour of docked heifers indicated changes in their sensitivity to heat and cold, similar to human amputees who experience phantom limb pain, indicating that similar mechanisms are present in the stump of the docked tail (Eicher et al., 2006). More fly-avoidance behaviours were observed (caused by increased fly attacks) on calves that had their tails docked. Fly counts have been observed to be greater on the rear limbs of docked 3-week-old calves during times of high fly activity (Eicher and Dalley, 2002). Tail-docked cows have shown elevated levels of fly-induced behaviour but they did not have an altered adrenal cortex function (Eicher et al., 2001). The only maintenance behaviour to be affected by banding and consequential tail necrosis was eating, which increased with banding and decreased with docking (Eicher et al., 2000).

Tail docking in beef cattle is mostly carried out under confined housing conditions in order to prevent tail tip necrosis. In some European countries (e.g. Austria, Germany), it is only allowed if other management measures have not been effective at preventing the occurrence of tail tip necrosis and is restricted to the amputation of a few centimetres of the tail tip (i.e. removal of the ligamentous part of the tail; Schrader et al., 2001). In fully slatted floor pens, such prophylactic tail tip docking reduced the prevalence of tail tip injuries and alterations (i.e. indurations, scales and cracks) but more severe lesions (e.g. purulent and necrotic lesions) were still more prevalent than on farms with straw pens (Schrader et al., 2001). Tail tip docked animals seemed to protect their tails by keeping them close to the body indicating hyperalgesia (Winterling and Graf, 1995).

#### 3.5.1.5. Dehorning and disbudding

Some new information is added to the text of Section 7.1.5. of the SCAHAW Opinion (2001).

In this Opinion disbudding means the removal of the horn buds in calves when the actual horn is still absent or very small (< 2 cm), which generally includes animals up to 2 months of age. Only two methods are usually used for disbudding calves – thermocautery (cauterisation with a hot-iron) and chemical cauterisation (caustic paste). The expression dehorning is used for older animals, in which actual horn removal is achieved by means of instruments such as a scoop, embryotomy wire, shears, saws, and others.

According to a large European survey carried out in 2008 (ALCASDE, 2009), 40 % of beef farms (which corresponded to approximately 40 % of beef cattle) kept bulls without horns. Of this population, 63 % were disbudded (52 % of these by hot-iron and 48 % by caustic paste) and 35 % were dehorned. About 2 % of the beef cattle population were from polled breeds.

Dehorned beef cattle are mainly found in the North of Europe but dehorning is seldom carried on in fattening bulls in the southern countries. For disbudding, the use of caustic paste appears to be more frequent in the South and the East of Europe, and it is being almost absent in the North where hot-iron disbudding is normally used.

In disbudding and dehorning, the drugs more frequently used are local anaesthetics, non-steroidal-anti-inflammatory drugs (NSAID) and sedatives, such as xylazine. For clarity in this Opinion, NSAID and sedatives have been combined in the risk assessment tables, but it should be noted that sedatives do not provide any analgesia. The ALCASDE (2009) survey showed that anaesthetic or analgesic treatment is administered to the animals prior to or after disbudding in only 35 % of beef cattle. The use of analgesia and sedation increases when dehorning is carried out on older animals (52 % of beef), since it is a more invasive procedure and animals are more difficult to restrain. In another European survey it was shown that NSAID were given to 50 % of cows that underwent Caesarean section, 55 % of claw amputations, and in only 1 % of dehorning cases (Whay and Huxley, 2005). In another study, 1.7 % and 4.6 % of the 605 respondents said they used NSAID after disbudding and castration, respectively. Also significant was the number of practitioners that used xylazine (17 %), lidocaine (74 %) or no drug (25 %) for these procedures (Huxley and Whay, 2006). A large US survey reported that some dairy owners used an anaesthetic (12.4 %) and analgesia (1.8 %) for dehorning (Fulwider et al., 2008).

In the large majority of European farms, the stockman was reported to be the main person in charge of calf disbudding (ALCASDE, 2009). Misch et al. (2007) found that 78 % of dairy producers dehorned their own calves but only 22 % used local anaesthetics, and it was also shown that producers who used local anaesthetics were 6.5 times more likely to have veterinary involvement in their dehorning decisions. Horn removal from older cattle was performed with frequent use of drugs and, therefore, it was more consistently carried out by veterinary practitioners, often with the assistance of the stockman.

Although disbudding/dehorning without pain management should be avoided, its effect has been included in the risk assessment to understand better the benefits of different analgesic protocols and because the majority of calves in Europe are still disbudded/dehorned without pain management.

Disbudding of female calves is carried out in almost all intensive dairy farms in Europe but males destined for the production of veal are very seldom disbudded. In contrast, young animals weaned from suckler herds and fattened in feedlots are frequently dehorned.

In young calves, the cautery iron (heated electrically or by gas) and caustic paste are the most commonly used methods for disbudding. In older animals (over 3 months old), dehorning is usually carried out by amputation (e.g. saws, embryotomy wire, guillotine shears, knifes or scoops; Stafford and Mellor, 2010).

Genetic selection of polled animals is undertaken in some breeds but although the genes for polling are dominant, this approach is not used effectively. Development of breed-specific DNA tests for the polled gene should make this welfare-friendly alternative to dehorning/disbudding more accessible (see Section 3.5.2. of this Opinion on genetics).

Caustic paste disbudding is usually carried out in very young calves (2 to 4 weeks of age) as long as the horn-growing tissue is readily identified. Farmers sometimes favour this method because it is easily performed. However, extra care has to be taken to prevent caustic paste running onto the face and into the eyes. Chemical cautery disbudding caused a significant but short-lived rise in cortisol that was largely complete 3 hours after applying the paste. Prior injection of a short-acting local anaesthetic (lignocaine) partially reduced the acute cortisol distress response and pain-related behaviours, but pain was only completely abolished when local anaesthesia was associated with a NSAID (flunixin-meglumine; Stilwell et al., 2008b, 2009). Tramadol given i.v. showed some effect on post-operative pain but was considered by the authors to cause insufficient analgesia (Braz et al., 2012). Vickers et al. (2005) performed a study with xylazine-sedated animals and suggested that this treatment alone was enough to control pain after caustic paste disbudding. As a cautionary note though, sedation may simply mask the signs of pain as opposed to providing pain relief.

Hot-iron disbudding that involves the application of thermocautery on the horn bud for 30 to 60 seconds, caused violent struggling during the procedure (Stilwell et al., 2007, 2012; Stewart et al., 2008b). It caused a significant but short-lived rise in cortisol that was largely back to baseline levels 2-3 hours after surgery. Local anaesthesia reduced struggling during the procedure and pain-related behaviours and plasma cortisol rose for a few hours afterwards, but only the combination of local anaesthesia and a NSAID (ketoprofen, meloxicam or carprofen) effectively controlled pain (Stafford et al., 2003; Stilwell et al., 2007, 2012; Heinrich et al., 2010).

Xylazine given before dehorning facilitated the administration of local anaesthesia and eliminated the need for restraint during the procedure, although it did not provide sufficient analgesia to eliminate the initial pain of horn amputation or hot-iron disbudding (Stilwell et al., 2010).

Dehorning by amputation (scoop-dehorning and other methods) is the preferred method for older calves (over 4 months) and is regularly used for weaned calves from beef herds. Since the scoop device has to be vigorously pushed against the animals' head and rapidly closed it is very difficult to predict the precise extension of tissue that is going to be cut, especially with animals that are struggling. For this reason some skin and bone are frequently cut with the horn bud and horn-growing tissue (Stilwell, 2009). Although dehorning using a scoop resulted in slightly higher cortisol concentrations than dehorning with a saw, guillotine shear, or embryotomy wire, there was little difference in distress displayed by 5- to 6- month-old calves in response to these methods (Sylvester et al., 1998).

When both lignocaine and ketoprofen (McMeekan et al., 1998) or flunixin-meglumine (Stilwell, 2008) were given prior to surgery, it virtually abolished the cortisol distress response to horn amputation throughout the first 9 hours after the operation.

On the basis that none or only little struggling during a procedure and lower overall cortisol distress responses are indicative of less pain and distress, the different procedures could be ranked as in Table 4.

**Table 4:** Ranking disbudding and dehorning procedures from most to least severe (the table was originally in Section 7.1.5. the SCAHAW Opinion, 2001, but it has been modified and updated).

| Rank | Procedure | Struggling | Severity[§] and duration of pain-related behaviours | Acute cortisol response |
|---|---|---|---|---|
| **6** | Amputation dehorning + wound cautery | During amputation and cautery | High < 9 hours | Marked (75 %)* |
| **5** | Amputation dehorning | During amputation only | High < 9 hours | Marked (100 %)* |
| **4** | Prior local anaesthetic[#] + amputation dehorning | None/little | High, after 2 hours until 9 hours | Marked (100 %)* but delayed |
| **3** | Hot-iron disbudding | During disbudding | Moderate < 3-6 hours | Moderate (55 %)* |
| **3** | Caustic paste disbudding | None/little | High-moderate < 3-6 hours | Moderate - marked (60 %)* |
| **3** | Prior NSAID + amputation dehorning | During amputation | Moderate (?) | Mild (35 %)* |
| **2** | Prior local anaesthetic# + any cautery disbudding | None/little | Low, after 2 hours and until 4 hours | Mild (35 %)* |
| **2** | Prior local anaesthetic# and NSAID + amputation dehorning | None/little | Mild | Very mild (25 %)* |
| **1** | Prior local anaesthetic[#] + amputation dehorning + wound cautery | None/little | Little | Very mild (25 %)* |
| **1** | Prior local anaesthetic[†] + thermal or chemical cautery disbudding + NSAID | None/little | Absent | Very mild (?) |
| **1** | Non-treated controls | None/little | Absent | Almost absent (< 20 %)* |

§In this context, severity and intensity are similar concepts.
*Percentage of the acute cortisol response to amputation dehorning in each study.
#Injected near the cornual nerve supplying each horn bud.
†Injected near the cornual nerve *and* around the base of each horn bud (Graf and Senn, 1999).
(?)Values or percentage not known.

In conclusion, dehorning is much more painful that disbudding. Dehorning, if carried out only under local anaesthesia, will cause severe pain, although this will be slightly delayed in time. Both cautery methods will cause pain for at least 6 hours, but animals disbudded by thermal cautery will struggle more during the procedure. Only nerve blocking with a local anaesthetic associated with a NSAID significantly reduces pain, independently of the method.

#### 3.5.1.6. Branding

No critical new information to be added to Section 7.1.6. the SCAHAW Opinion (2001).

#### 3.5.1.7. Glossectomy

New section.

It has been reported that as many as 25.2 % of the primiparous cows and buffaloes, and 4.3 % of the multiparous cows and buffaloes were observed to suffer from inter-sucking or self-sucking. Sometimes amputation of the tip of the tongue or slicing off the tongue’s ventral surface (partial glossectomy) is carried out to prevent young animals continuing to suck their dams, themselves or other females in the herd (Anonymous, 1975; McCormack, 1976). Although there are no published studies on the welfare impact of this procedure, it is reasonable to assume that it has very severe negative consequences on the welfare of the animal. An alternative to this method, besides management procedures, such as separating or culling these animals, is the use of a modified bull nose ring with spines to the suckler animals.

***Conclusions***

1. Addition to Conclusion 1. of Section 7.1. of the SCAHAW Opinion (2001; see UC.6 in the Conclusions and Recommendations section): Castration is carried out to reduce sexual activity and accelerate fattening. Pain may continue for weeks after castration. Weight loss increases as the age of castration is increased and is independent of the method used.

2. New evidence suggests that castration by rubber ring alone is less painful than a combination of Burdizzo and rubber rings.

3. Addition to Conclusion 2. of Section 7.1. of the SCAHAW Opinion (2001; see UC.7 in the Conclusions and Recommendations section): Immunocastration has been shown to reduce aggressive and sexual behaviour of treated bulls. Surgical castration may lead to complications, such as haemorrhage, infection, severe inflammation and tetanus.

4. Addition to Conclusion 3. of Section 7.1. of the SCAHAW Opinion (2001; see UC.8 in the Conclusions and Recommendations section): Spaying causes pain, may lead to complications, such as peritonitis, and its indications can be replaced by management decisions.

5. Addition to Conclusion 4. of Section 7.1. of the SCAHAW Opinion (2001; see UC.9 in the Conclusions and Recommendations section): The tail is essential for insect control.

6. Addition to Conclusion 5. of Section 7.1. of the SCAHAW Opinion (2001; see UC.10 in the Conclusions and Recommendations section): Approximately 15 % of beef cattle in Europe are dehorned.

7. Addition to Conclusion 6. of Section 7.1. of the SCAHAW Opinion (2001; see UC.11 in the Conclusions and Recommendations section): Approximately 35 % of beef cattle in Europe are disbudded. Disbudding or dehorning under sedation only (e.g. xylazine) will result in severe stress and pain.

8. Partial glossectomy, to prevent cross-sucking, causes severe pain and discomfort.

9. Young animals are as sensitive to pain as older animals but the trauma involved in mutilations is much greater in older animals.

10. Addition to Conclusion 5. of Section 2.2. of the SCAHAW Opinion (2001; see UC.1 in the Conclusions and Recommendations section): Tthe amount of tissue affected by mutilations is usually greater in older animals, resulting in a more extensive area of pain and a more prolonged recovery.

***Recommendations***

1. Animals at any age should always be provided with local or regional anaesthesia at the time of surgical mutilations, as well assystemic analgesia for two days thereafter.

2. Addition to Recommendation 3 of Section 7.1. of the SCAHAW Opinion (2001; see UR.5 in the Conclusions and Recommendations section): Rubber ring castration should only be used in animals only under the age of 2 months and the scrotum should be cut after 8-9 days of ring application. Surgical castration should only be performed by a veterinarian.

3. Addition to Recommendation 5 of Section 7.1. of the SCAHAW Opinion (2001; see UR.6 in the Conclusions and Recommendations section): The anaesthesia must be local or regional and accompanied by prolonged systemic analgesia. Disbudding under sedation of alpha-2 adrenergic receptor agonists, such as xylazine, should only be carried out in combination with a (local) anaesthetic and analgesic.

4. Cautery should be preferred over the use of caustic substances. If caustic paste is to be used care must be taken to avoid it running onto the face or being licked by other animals.

5. Glossectomy to any degree should be prohibited.

### 3.5.2. Genetics

Section 7.2. of the SCAHAW Opinion (2001), has been re-written to reflect the new developments in the field of genetics.

In the previous Opinion (SCAHAW, 2001), this section was written from the quantitative (or classical) genetics point of view but, iIn the last decade, DNA technology has revolutionised the field. Genomics and other “omics” tools have emerged, which have created new opportunities for the “new genetics”.

#### 3.5.2.1. Domestication

Domestication is the process whereby populations of animals change genetically in order to adapt to an environment where reproduction is controlled largely by man (Price, 1997).

The opportunity to express certain behaviours is an important part of several animal needs and hence there is a necessity for good welfare. Domestication and subsequent selection, first with emphasis on adaptation followed by production, has moulded the gene pool in ways that affect every trait, including behaviour. The previous Opinion stated that “the behavioural changes caused by domestication are quantitative rather than qualitative in nature”, and that “the potentiality to perform most - if not all - "natural" behaviours still exists in domesticated animals”.

Recent studies have shown several important changes induced by domestication (Jensen and Andersson, 2005), and they included changed ontogenetic processes, increased social tolerance, altered sexual and reproductive behaviours, and an adaptive ability that has been affected in different ways. Defining “normal” behaviour for highly productive domesticated livestock should, therefore, consider these changes, as well as perhaps others that are still to be documented. To accomplish this goal, research efforts aimed at understanding the genetics and genomics of natural behaviour and other welfare relevant traits are needed. Modern genomics offers tools to achieve these goals and they may also provide biological insights into why and how intense selection for production traits may have led to welfare problems. This knowledge may also provide new practical tools for developing breeding programmes where animal welfare can be given a much higher weight than today. Inclusion of selection against abnormal and damaging behaviour in animal breeding programmes has a large potential for increasing the welfare of animals used by man.

#### 3.5.2.2. Genetic variability

Any trait that has genetic variability can be modified through selection but the changes brought about are not limited to the trait selected for. All other traits genetically correlated with the selected trait will also change, and the magnitude and direction of the change is dependent on the size and sign (positive or negative) of the genetic correlation.

Production-related traits receive most emphasis and a description of National Genetic Evaluation Systems for beef cattle as applied in different EU Member States, is shown in Table 5. Interbeef, a working group of ICAR (International Committee of Animal Recording, online), was recently established to facilitate the international sharing of beef data between breeding organisations, and to facilitate the international genetic evaluation of breeds and traits in each participating beef population. It has considerable potential to improve the accuracy of local genetic evaluation, increase the size of the genetic pool and encourage the exchange of germ plasm between populations. The Interbull Centre (EU Reference Laboratory for Zootechnics-bovine breeding, online), which is part of the Swedish University of Agricultural Science in Uppsala, Sweden, is the operational unit of Interbeef.

In addition to the traits listed in Table 5, breeding organisations in various countries consider other traits in their evaluation programmes, particularly carcass and maternal ability-related traits. In Europe (for instance in France and Belgium), genetic selection in cattle has been directed towards high muscle development at the expense of fat in order to produce leaner carcasses and increase meat production. Genetic selection in favour of muscle growth leads to a higher proportion of fast-twitch glycolytic fibres at the expense of slow-twitch oxidative fibres (Bouley et al., 2005; Sudre et al., 2005). It is important to evaluate whether these changes in proportion of muscle fibre types, associated with genetic selection for increased muscularity, have a negative effect on the welfare of beef cattle. Intense and unilateral selection for production traits in dairy cattle, pigs or broilers has led to considerable negative consequences for animal welfare (Rauw et al., 1998).

Lessons learned from these examples, combined with increasing demand by consumers for safe high-quality meat, while respecting animal health and welfare and protecting the environment, indicate that for beef production systems to be sustainable they need to broaden their breeding goals to include health and other important welfare traits in order to prevent undesirable welfare consequences in beef cattle. Genomics and related technologies offer great opportunities for genetic improvement in welfare-related traits, such as disease resistance, fertility, heat tolerance and temperament.

Several genomic initiatives are being conducted all over the world (e.g. AGENAE in France, FUGATO in Germany, the Biotechnology Initiative of Teagasc in Ireland, NAGRP in the USA, SheepGENOMICS, and Beef CRC in Australia) and should contribute to making genomics fully operative in animal science in the near future. For example, the french National Institute for Agricultural Research (INRA) launched its own animal genomics programme in 2000-2001 in four main species (cattle, pig, chicken, and trout). In 2002, a cooperative research programme, called AGENAE (acronym for Analysis of the genome of farm animals) was initiated (Chevalet et al., 2007), and it is piloted by a consortium consisting of state-supported research organisations and private associations representing the farm animal industry. The French livestock industry, especially the beef industry, has expended great effort and resources to identify possible genomic markers that would identify animals with desirable traits. The AGENAE programme covers many fields of interest, such as reproduction, growth and development, health, behaviour and welfare, milking ability, and quality of animal products.

Genomics should lead to new ways to improve health and welfare, as well as performance. New genomic knowledge provides opportunities to improve temperament, disease diagnosis, detection of predisposition to disease, and enhance development of new treatments (Cassar-Malek et al., 2008).

**Table 5:** Description of National Genetic Evaluation Systems for beef cattle as applied in different EU member countries (as of Jan 2011; Interbull, online).

| Country | Weaning weight | Carcass conformation | Carcass weight | Calving ease |
|---|---|---|---|---|
| Denmark | CHA, LIM | CHA, LIM | CHA, LIM | CHA, LIM |
| Czech Republic | ALL | ALL | ALL | ALL |
| Finland | CHA, LIM | | | |
| France | CHA, LIM | | | CHA, LIM |
| Germany | ALL | | | ALL |
| Ireland | CHA, LIM | ALL | ALL | ALL |
| Spain | LIM | | | |
| Sweden | ALL | | | |
| United Kingdom | LIM | LIM | LIM | LIM |

CHA: Charolaise; LIM: Limousine; ALL: all breeds

#### 3.5.2.3. Double-muscling

The Belgian Blue cattle breed (BBCB) is notorious for its exceptional muscular development known as “double-muscling”. This extreme phenotype is due in part to an 11-bp loss-of-function deletion in the myostatin gene (Grobet et al., 1997) that has been fixed in the breed, and to selection of unidentified polygenes influencing muscularity. The previous Opinion points out that BBCB cattle, as well as double-muscled animals found in other European breeds (e.g. Charolais, Piemontese), have more trouble coping with their environment, show earlier signs of fatigue during forced exercise, are more susceptible to heat stress and to fasting stress, are usually more excitable, have an increased reaction to stress and a high frequency of dystocia (Arthur, 1995).

In BBCB and other breeds, intense selection has substantially reduced the effective population size (i.e. genetic diversity). Extensive reliance on artificial insemination (AI), in particular, by allowing popular sires to have thousands of descendants, narrows the genetic basis. The concomitant increase in the rate of inbreeding causes recurrent outbreaks of recessive defects. Inherited defects that have lately afflicted the BBCB include the recently described Congenital Muscular Dystonias (CMD) I and II. The genes underlying CMD I and II were readily mapped, and the causative mutations in the *ATP2A1* and *SLC6A5* genes identified. The widespread use of the resulting diagnostic tests has allowed immediate and effective control of the corresponding pathologies (Charlier et al., 2008).

Fasquelle et al. (2009) identified a loss-of-function mutation of the bovine *MRC2* gene that increased muscle mass in heterozygotes, yet caused skeletal and muscular malformations known as Crooked Tail Syndrome (CTS) in homozygotes. As a result of the “heterozygote advantage”, the MRC2 c.2904_2905delAG mutation has swept through the BBCB population, resulting in as many as 25 % carrier animals that have caused a sudden increase in CTS cases.

As these recently discovered genetic defects show, increased inbreeding and associated reduction in population size is undesirable and measures should be taken by AI organisations to limit their increase or decrease it via out-crossing, perhaps by importing semen from unrelated populations. When genetic-caused defects are discovered, they should be eliminated from populations as soon as possible through the use of gene marker tests.

#### 3.5.2.4. Reaction to human handling

Throughout the productive life of beef cattle many stressful events occur (e.g. branding, castration, vaccination and tagging) that are coupled to weaning, social mixing, and transportation. These stressful events have been reported to induce secretion of several of the prominent stress-related hormones: cortisol, adrenaline, and noradrenaline (Buckham Sporer et al., 2008). Some stimulation that involves short-term poor welfare is not necessarily detrimental to the health of an animal, and may even be beneficial (Dhabhar, 2002; Duff and Galyean, 2007; Sorrells and Sapolsky, 2007). However, chronic stress can negatively impact growth, reproductive function, and immune function (Dobson et al., 2001). Therefore minimising adverse consequences of multiple stressful incidents, as well as identification of animals that may react differently to multiple stressful events, may be beneficial to beef cattle welfare.

The effect of animal temperament on welfare is an area of increasing research interest. Specifically in cattle, temperament is indicated by the reactivity, or fear response to humans. Correlations between temperament and concentrations of stress hormones in cattle have been reported with more excitable, cattle having greater concentrations of cortisol and adrenaline (Schuehle et al., 2005; Curley et al., 2006, 2008; King et al., 2006). Multiple studies have provided valuable information on the relationships between cattle temperament, transportation, immune challenges, and production traits over the last six years. For example, temperament can have negative impacts on growth (average daily gain), carcass traits, and immune function in cattle with less desirable temperaments compared with calmer cattle (Fell et al., 1999).

Temperament assessments of beef cattle can be comprised of several subjective and objective tests. Three of the most common measurements are: 1) chute score, 2) pen score, and 3) exit velocity. While chute and pen scores are subjective measures of temperament, exit velocity is an objective measurement that records the rate (m/s) at which cattle exit a working chute (Burrow et al., 1988; Curley et al., 2006). Pen score (Hammond et al., 1996) is a subjective measurement in which cattle are separated into small groups of three to five and their reactivity to a human observer is then scored on a scale of 1 (calm, docile, and approachable) to 5 (aggressive, volatile, and crazy). Chute scores reflect the behaviour of the animal while confined in a chute and they are scored on a scale of 1 (calm, no movement) to 5 (rearing, twisting of the body, or violent struggling; Grandin, 1993). Utilisation of a temperament score, which is the average of the exit velocity and pen score, provides a combined temperament measurement that encompasses both the subjective and the objective perspectives (Curley et al., 2006; King et al., 2006).

As pointed out in the previous Opinion, temperament is moderately heritable and, as described above, the phenotype can be quantified using a set of well-defined measures. A selection programme to improve this trait genetically can be implemented with relative ease and, in addition to improving performance, could provide substantial welfare benefits.

#### 3.5.2.5. Health

Health control and health service activities are important measures toward improved welfare. Historically, management of disease focused on prevention of infectious diseases by biosecurity, batch wise production (see also Section 3.5.4.) and modifying the animals' environment through low stress handling and optimal housing conditions, the treatment of clinically ill animals and, when applicable, by vaccination, control and eradication of specific infections. The previous Opinion mentioned the existence of breed differences with respect to several diseases, pointing out that the genetic component plays an important role in the health of beef cattle. Until recently, little attention has been given to the potential for genetic improvement of health-related traits. Much of this is most likely to be due to one of the greatest weaknesses in current cattle evaluation, a lack of tools from which to make these selection decisions. In turn, this lack of tools probably springs from the difficulty to identify the economically-relevant traits related to animal health. The term "health" includes a vast array of potential traits for selection.

At a basic level, health traits fall into three general categories. The first group contains those diseases that are the result of a defect in the individual's genetic composition, such as osteopetrosis, arthrogryposis multiplex, fawn calf, tibial hemimelia, etc. (genetic defects). The second class contains those diseases associated with non-transmissible environmental challenges, such as fescue toxicity, facial eczema, eye cancer in white-faced Herefords, or high-altitude (brisket) disease (environmentally-induced diseases). These diseases are also described as directly related to adaptability. The final class represents those diseases related to some specific disease vector or pathogen that can be bacterial, viral or parasitic in nature (pathogen-associated diseases). There are enormous opportunities to capitalise on genetic variability and implement programmes to improve the health traits in all three of these disease categories.

To illustrate these opportunities, examples of recent successes for each disease category are described.

Genetic defects

Marble bone disease, also known as osteopetrosis, had not been seen in the United States before the 1960s, when it appeared in Black Angus. Osteopetrosis is a deadly birth defect that affects humans, cattle and other animals, and causes abnormal development of the brain cavity and bone marrow cavity, leading to overly dense, brittle bones that shatter easily. Scientists found that a region on cattle chromosome 4, which contains *SLC4A2* - a gene essential for proper osteoclast maintenance and function - was associated with the disease (Meyers et al., 2010). Some of the *SLC4A2* genetic material in the osteopetrosis-affected calves had been deleted. Within months, a polymerase chain reaction (PCR) test was developed and is now available to breeders. These tests have been very successful in identifying animals carrying a specific deleterious recessive gene. These genetic tests and those described for the Belgian Blue breed are evidence of our potential to improve health traits belonging to the first category.

Environmentally-induced diseases

There are opportunities for genetic improvement with respect to environmentally-induced disease (second class). A good example is high-altitude disease, which is commonly referred to as brisket disease. This disease manifested itself in cattle in environments above an elevation of 1,800 m as a swollen brisket area, with reduced appetite, reduced thriftiness (poor doing) and eventual death. Physiologically, the disease is the result of lower concentrations of oxygen at higher elevations. In a low-oxygen environment, the heart responds vigorously by forcing blood through the pulmonary system, which in turn forces fluid out of the circulatory system, thus resulting in the swollen brisket. Pulmonary artery pressure (PAP) was identified as a good indicator for this disease and, since it is heritable ($h^2$=0.46), it should therefore respond to selection (Fagan and Weil, 2004; Holt and Callan, 2007). This indicator was used in selection of breeding stock in a Colorado ranch and the effect was a consistent positive trend manifested by lower incidence for the disease and a milder effect for animals experiencing the disease.

Pathogen-associated diseases

The class of animal health traits associated with pathogens presents similar difficulties for genetic improvement. The challenge lies in identifying the economically relevant traits, defining associated indicator traits, developing appropriate data sets, and identifying DNA marker tests to enable the implementation of genetic evaluation and selection.

Although the number of traits that benefit from DNA testing continues to grow, most of these traits represent the easier work (i.e. traits that already had a large amount of performance data available for calculating genomic predictions). Genomic predictions have the potential to increase the accuracy of genetic predictions for all traits, but their impact will be greatest on traits for which there is presently no collection of performance data. Beef breed associations do not collect performance records for animal health traits, and thus it is these traits that are likely to benefit most from the development of genomic predictions.

The three most prevalent bacterial diseases that affect feedlot cattle are pinkeye, foot rot and bovine respiratory disease, and they can be used in combination to represent overall pathogenic disease incidence. Bovine respiratory disease is responsible for 75 % of feedlot morbidity and about 70 % of all deaths in beef cattle in the United States (Casas et al., 2011a; Kuehn et al., 2011). Pinkeye can affect up to 80 % of a herd (Casas and Stone, 2006; Kizilkaya et al., 2011) while foot rot, which causes lameness, also has substantial prevalence in some environments. The welfare of cattle affected by any one of these diseases is drastically reduced.

Combining incidence data for all three diseases allowed researchers (Ruminant Diseases and Immunology Research Unit at the ARS National Animal Disease Center in Ames, Iowa) to look at resistance to multiple diseases (Casas et al., 2011b). A DNA marker associated with these diseases was found on bovine chromosome 20. This genetic marker is in very close proximity to several markers related to other diseases, such as Johne's disease and bovine viral diarrhoea. This particular region on chromosome 20 may have a significant effect on the general health of animals. The next steps are validation of these markers and development of DNA tests the beef industry can use to implement an effective selection programme to increase resistance to these diseases and, therefore, improve welfare.

Another indicator of bovine health for which performance data is unavailable is vaccine response. When vaccines are administered to a herd, it is often assumed that the entire herd mounts an equally protective response to the vaccine. In reality, vaccine response varies and some individuals will mount a stronger than average response to the vaccine, while other individuals will mount a weak response, or no response at all (i.e. "non-responders"). Traditionally, researchers have focused on improving vaccines so that a larger percentage of the population is protected after vaccination. However, a complementary approach would be to select for cattle that respond strongly to currently available vaccines. If genomic predictions can be developed for vaccine response, it will be possible to select for animals that mount a strong immune response to available vaccines, thus better protecting vaccinated animals from disease. Recent research has looked at variation in the individual animal response to vaccination against bovine viral diarrhoea (BVD) by checking blood antibody levels. Results have suggested that the response was at least partially controlled by genetics (Gonda, 2011). Similar research is underway looking at variation in the response to vaccination for BRD.

These studies represent only the first steps towards development of a DNA test for vaccine response. After discovery and validation of the DNA markers associated with vaccine response, the next step will be to implement selection and management programmes based on these markers.

It is clear that in each of the three categories of health-related traits there is evidence for a substantial genetic component. In two of the three categories, selection tools have been successfully developed and marked genetic progress has been made. In the category of pathogen-associated disease, genetic variability in resistance to these diseases exists and rapid progress is being made toward implementation of data collection and identification of DNA markers. In addition, the development of tests that can be used in marker assisted selection (MAS) is critical in order for the beef industry to capitalise on these opportunities. Health of food animals needs to be improved permanently through genetic strategies in order to decrease dependence on vaccines and drugs, and to improve food safety and welfare. These research efforts should be encouraged because implementation of marker-assisted selection to improve genetic resistance to pathogen-associated disease should lead to the development of animals that have superior immune systems that can tolerate environmental challenges that impair health. Subsequently, this should also bring about substantial improvement in health and welfare of beef cattle.

Availability of DNA markers will also be used in marker-assisted management (MAM) and this should bring about immediate welfare benefits. It is easy to envisage positive effects associated with the use of DNA marker information in order to sort cattle entering a feedlot based on resistance to diseases, or the response to vaccination, or temperament, etc., then place them in different pens and manage each group accordingly.

#### 3.5.2.6. Genetic option to replace dehorning in beef cattle

Dehorning is used to address the problems associated with horns in cattle, but dehorning only prevents the injurious outcome without actually addressing the basic problem. There is growing interest in finding a genetic solution to this problem due to animal welfare concerns associated with dehorning (Prayaga, 2007; Capitan et al., 2009). Breeding polled cattle is a non-invasive, welfare-friendly method of replacing the practice of dehorning.

Although progress is being made, currently available DNA tests for identifying homozygous poll cattle are applicable only to certain breeds and they can give inconclusive results. To achieve significant advances in replacing the practice of dehorning through breeding of polled animals, more accurate DNA tests for identifying homozygous polled animals are needed.

Research to develop an accurate breed-specific DNA test for the poll gene is needed. Breed societies should engage with the cattle industry to overcome certain misconceptions about breeding polled cattle. Specific polled-bull breeding programmes need to be developed by the beef breeding industry to increase the number of polled bulls available.

***Conclusions***

1. Addition to Conclusion 2 of Section 7.2. of the SCAHAW Opinion (2001; see UC.13 of the Conclusions and Recommendations section): Genetic selection in favour of muscle growth leads to a higher proportion of fast-twitch glycolytic fibres at the expense of slow-twitch oxidative fibres.

2. Temperament of beef cattle is moderately heritable and the phenotype can be quantified using a set of well-defined animal-based measures.

3. Addition to Conclusion 7 of Section 7.2. of the SCAHAW Opinion (2001; see UC.15 of the Conclusions and Recommendations section): New solutions using genetic markers are available for the welfare problem caused by dehorning/disbudding. Breeding polled cattle is a non-invasive, welfare friendly method for replacing the practice of dehorning.

***Recommendations***

1. Addition to Recommendation 6. of Section 7.2. of the SCAHAW Opinion (2001; see UR.8 of the Conclusions and Recommendations section): Research to develop an accurate breed-specific DNA test for the poll gene is needed. Breed societies should engage with the cattle industry to overcome certain misconceptions about breeding polled cattle. Specific polled-bull breeding programmes need to be developed by the beef breeding industry to increase the number of polled bulls available.

2. Research is needed to assess if the changes in proportion of muscle fibre types associated with genetic selection for increased muscularity has a negative effect on the welfare of beef cattle.

3. A selection programme should be implemented to genetically improve temperament in beef cattle in order to achieve substantial welfare benefits.

4. Research efforts aimed at developing tools needed for implementation of marker-assisted selection to improve genetic resistance to pathogen-associated diseases should receive high priority, since genetic improvement of disease resistance will also achieve substantial, permanent and cumulative improvements in welfare of beef cattle.

### 3.5.3. Nutrition and feeding

Section 7.3. of the SCAHAW Opinion (2001) has been re-written to provide a more comprehensive review of developments in the field of nutrition both before and after 2001.

The welfare of any animal clearly depends on the provision of sufficient food to supply principally energy (Metabolisable Energy, ME) and other nutrients, proteins, amino acids, fatty acids, minerals and vitamins, which are essential for the functions of life: maintenance, activity, reproduction and growth. Failure to provide sufficient ME can lead to severe loss of body condition, infertility and ultimately death from starvation. Failure to provide optimal amounts of specific nutrients, such as copper and magnesium, can lead to severe metabolic disorders. Nutrient requirements and problems associated with nutritional deficiencies (and excesses) were reviewed briefly by SCAHAW (2001). More recent research in beef cattle nutrition is reviewed here. However, the impact of feeding and food provision on cattle welfare involves much more than simply an evaluation of nutrient requirements and nutrient supply.

In order to meet the physiological, health and behavioural needs of beef cattle, the feed must satisfy four essential criteria (Webster, 2009):

- Provision of adequate and balanced amounts of ME and all other essential nutrients as required for maintenance, activity, reproduction and growth.

- Provision of feed of a physical and chemical composition consistent with stable fermentation in the reticulo-rumen and healthy digestion in the gastro-intestinal tract.

- Provision of feed in a form that provides oral satisfaction (e.g. rumination) and does not predispose to stereotypic behaviour.

- Provision of feed that does no harm, through inclusion of toxic substances, pathogens and antinutrients, etc.

The number of references relating to cattle nutrition published since 2000 is very large. In most cases, there is no need to make a functional distinction between beef and dairy animals, although there are significant differences of degree: dairy cows are at greater risk of problems associated with high ME intake and metabolic demand, whereas beef cattle at pasture are at greater risk of mineral deficiency diseases. Most publications, identified under the headings of feeding and nutrition, describe feeding trials or biochemical reactions associated with fermentation and digestion and are not relevant to this mandate. The publications considered in this review are those that have a bearing on problems of welfare and disease associated with ruminant digestion and metabolism.

#### 3.5.3.1. Nutrient requirements and supply

New information is added to the text of Section 7.3.2. of the SCAHAW Opinion (2001).

The most recent comprehensive report of nutrient requirements is that prepared by the National Research Council of the USA (NRC, 2001). However, there have been more recent developments in evaluating feeds in terms of nutrient supply to ruminants based on models that recognise the two-stage process of digestion and absorption: carbohydrate fermentation in the rumen, with absorption of ME as volatile fatty acids and synthesis of microbial protein, followed by gastrointestinal digestion and absorption of unfermented energy, microbial and undegraded dietary protein. Models in common use include the Cornell Net Carbohydrate and Protein System (CNCPS; Fox et al., 1992) from the USA, the Metabolisable Energy and Protein systems from the UK (Alderman and Cottrill, 1993) and the INRA (Institut National de la Recherche Agronomique**,** INRA, 1989) system developed in France. Tedeschi et al. (2005) examined and compared the precision of these models. They are all superior to older systems for calculating nutrient requirements because they make the distinction between the nutrient requirements of the microorganisms in the anaerobic environment of the rumen and the nutrient requirements of the host animal. Provision of a balanced supply of nutrients to the rumen microorganisms not only promotes optimal performance and feed conversion efficiency, it also reduces the risk of welfare problems arising from disorders of fermentation, such as ruminal acidosis and parakeratosis of the ruminal epithelium.

The rate at which ruminant digestion can supply nutrients for maintenance and production is primarily limited by the rate of carbohydrate fermentation in the rumen. Ruminants consuming grass at pasture obtain most of their carbohydrate in the form of digestible fibre (principally cellulose). Other sources of digestible fibre include conserved forages and fibrous crop residues such as beet pulp. Highly digestible grasses and forages (> 70 %) can provide sufficient ME for maintenance and high levels of production (e.g. > 1 kg weight gain/day in beef cattle). When the digestibility of fibre is low (< 40 %) adult cows and (especially) young beef cattle are unable to obtain enough ME for maintenance and they lose body condition. The capacity of a ruminant to consume fibrous feeds is constrained not only by the rate of fermentation but also by the bottleneck to rumen outflow provided by the reticulo-omasal orifice. When digestibility is low, a ruminant may suffer simultaneously from metabolic hunger arising from inadequate ME supply, exacerbated by inappetance resulting from a rumen impacted with indigestible fibre. In brief, the animal may be said to be simultaneously hungry and full up. Clearly the magnitude of this problem increases with increasing metabolic demand for growth, pregnancy and lactation.

In diets for highly productive animals (e.g. fast growing beef cattle), fermentable carbohydrate supply is normally provided from a mixture of digestible fibre and starch from cereals (barley, maize). Starch ferments very rapidly in the rumen and can therefore greatly increase the rate of ME supply. Moreover, starch fermentation yields a higher ratio of the glucogenic volatile fatty acid propionate to ketogenic acetate, than cellulose fermentation. This is consistent with increased feed conversion efficiency and reduced methane production. However, excessively rapid fermentation predisposes rumen acidosis, accompanied by destruction of many of the normal rumen bacteria and protozoa, with potentially extreme consequences for welfare, including abdominal pain, metabolic acidosis and, in severe cases, death. The optimal diet for a highly productive ruminant is that which can meet the nutrient requirement for ME, while maintaining a stable pattern of fermentation within the rumen (pH > 6.0). In practice, many diets for beef cattle intensively reared or rapidly finished on feedlots carry the risk of promoting unstable rumen fermentation, leading to acute and recurring problems of acidosis with secondary complications, such as laminitis and rumen parakeratosis. Several feed additives (e.g. sodium bicarbonate, bentonite, yeast cultures) are marketed principally as stabilisers of rumen fermentation, and these are discussed in more detail in the following sections.

#### 3.5.3.2. Digestion and digestive disorders

This section replaces 7.3.3 Section of the SCAHAW Opinion (2001) “Metabolic disorders in relation to different feeding regimes”, with the addition of new information.

Growing beef cattle, housed, yarded or on feedlots, and presented with high energy rations *ad libitum*, are at risk of digestive disorders. The most common of these is subacute ruminal acidosis, which occurs when the fermentation rate exceeds the buffering capacity of the rumen (see above). In brief, the fermentation rate increases with the increasing ratio of rapidly fermented starch to plant fibre: slowly fermentable cellulose and hemicellulose, plus unfermentable lignin (Neutral Detergent Fibre, Van Soest, 1982). The buffering capacity of the rumen is primarily determined by salivation rate, which increases with increasing rumination time, itself determined by the amount of “physically effective fibre” (Yang and Beauchemin, 2009; Zebeli et al., 2010), with one factor being chop length > 15 mm, that requires comminution by regurgitation, rumination and reingestion.

<u>Ruminal acidosis</u>

Studies of the aetiology and pathogenesis of ruminal acidosis have been reviewed recently by Kleen et al. (2003) and Vasconcelos and Galyean (2008). Ruminal acidosis occurs as a result of excessively rapid fermentation of starchy cereals, which lowers rumen pH and fosters the production of toxic factors. Acute ruminal acidosis, characterised by a ruminal pH of less than 5.0 or 5.2, typically occurs following the accidental consumption of a gross excess of cereals (e.g. when hungry cattle gain sudden access to large quantities of grain). This clearly represents a serious failure in management. Beef cattle fattened on high cereal diets are at risk from subacute, recurring ruminal acidosis (SARA). Rapid fermentation, causing rumen pH to fall below 5.5, causes selective destruction of microorganisms involved in normal fermentation, including *Streptococcus bovis* and Protozoa, and favours the development of lactobacilli (Nagaraja and Titgemeyer, 2007). In cases of SARA (as distinct from acute acidosis arising from acute grain overload), buffering of absorbed lactic acid by plasma bicarbonate, for instance, is usually sufficient to prevent a clinically harmful fall in blood pH although changes in blood gases and pH, can be used for diagnostic purposes (Gianesella et al., 2010). In SCAHAW (2001), this condition was erroneously described as metabolic acidosis, when, in fact, the primary disorder is of ruminal origin. Secondary disorders associated with SARA may be local (e.g. hyper- and parakeratosis of the rumen epithelium) or systemic (e.g. hepatic abscesses and laminitis in hoof horn). The exact aetiology of these secondary conditions remains obscure, although they do appear to be linked with the absorption of endotoxin and intact bacteria across the damaged rumen wall and into the portal circulation.

SARA can be effectively controlled through provision of adequate long fibre, which reduces the fermentation rate and stimulates rumination, salivation, and thereby the flow of bicarbonate buffers into the rumen. This was described in SCAHAW (2001). However, the new concept of physically effective fibre, which incorporates information on chemical NDF content and fractions of diet particles, linked to measures of degradation of different raw and treated starches, enables the formulation of high ME diets that carry a very low risk for SARA (Yang and Beauchemin, 2009; Zebeli et al., 2010).

However, this natural approach tends to reduce ME intake and weight gain. In consequence, there has been much research into the potential of feed additives to stabilise rumen pH, and thereby sustain productivity and rumen health, while continuing to feed high cereal diets. Additives include buffering mixtures (Petrujkic et al., 2010), amylase inhibitors (McLaughlin et al., 2009; Blanch et al., 2010), ionophores (monensin, Mutsvangwa et al., 2002), yeasts (*Saccharomyces*, Thrune et al., 2009), probiotics (*Prevotella bryantii*, Chiquette et al., 2008), and lactate utilising bacteria (e.g. *Megasphaera elsdenii*, Henning et al., 2010). The attraction of these additives to producers, and especially to the feed industry is that they appear, in some reports, to improve weight gains and feed conversion efficiency. However, the results are inconsistent, although the most positive results, unsurprisingly, are obtained with buffering mixtures. Trials with yeasts and ionophores are mostly positive. More radical approaches using, for instance, probiotics and lactate utilising bacteria, are still equivocal. It is important to point out that “positive” results (e.g. with yeast mixtures) do not imply an absolute gain in terms of feed utilisation, merely that these palliative products have reduced the risk of abnormal fermentation in the rumen leading to SARA and possible sequelae such as parakeratosis, liver abscesses and laminitis.

Parakeratosis and liver abscesses

The pathological changes in rumen function during acute and subacute acidosis include increased osmolarity, which negatively affects absorption and destruction of many normal species of rumen organisms, with the production of endotoxin and amides, such as histamine (Vasconcelos and Galyean, 2008). This is accompanied by structural changes frequently leading to parakeratosis (Steele et al., 2011). At the same time, other microorganisms increase in numbers. These include *Fusobacterium necrophorum* (Tadepalli et al., 2009), *Escherichia coli* and *Lactobacillus* species (Schwartzkopf-Genswein et al., 2003). Strains of *E.coli* include the antibiotic-resistant and zoonotic strains such as O157 and there is evidence from the USA that the presence of antibiotic resistant strains has been increased through the routine administration of subtherapeutic levels of antibiotics (Alexander et al., 2008). *F. necrophorum* has a number of virulence factors that have been shown to cause inflammatory responses in the rumen epithelium that can lead to the chronic inflammatory and structural changes described as hyper- or parakeratosis. *F. necrophorum* is also consistently recovered from liver abscesses (Nagaraja et al., 2005). There is overwhelming evidence that SARA is the major risk factor for parakeratosis and that parakeratosis is a major risk factor for liver abscess. Other possible risk factors include primary infections of the foot (digital dermatitis). The prevalence of liver abscesses observed at slaughter in batches of feedlot cattle in the USA has ranged from < 5 to > 90 % with 15-20 % considered ‘normal’ (Corbière et al., 2008). The prevalence has been reduced by routine treatment with tylosin (Nagaraja et al., 2005) but this is banned in the EU. Vaccines against *F. necrophorum* are available and have been used with varying success (Fox et al., 1992; Checkley et al., 2005). Liver abscesses are associated with reduced growth rates but their effect on welfare is unknown.

Feed-related laminitis

In the majority of herds of dairy cattle within the EU the prevalence of foot lameness in dairy cattle is between 15-30 % (EFSA, 2009). In most of these cases, the lameness results from a primary disorder in the hoof horn (e.g. sole ulcer) or infection in the surrounding skin (EFSA, 2009). True laminitis, involving damage to the laminar capillaries of the hoof, with associated inflammation and severe pain, is relatively rare in dairy cows but can present severe problems for beef cattle on high starch, low fibre rations. The aetiology is somewhat obscure but ruminal acidosis leading to the release of endotoxin and histamine has been cited as a likely contributor. Lameness can be a serious problem for beef cattle on high grain rations that experience SARA. True laminitis in the claw horn may be due to release of endotoxin. “Foot rot” infections, arising primarily in the skin surrounding the hoof horn, may result from bacteraemia associated with *F. necrophorum* absorbed across a damaged rumen wall (Nagaraja et al., 2005). However, rapid growth of hoof horn in cattle fed to achieve high growth rates and bedded on straw may be a separate or contributory cause.

Polioencephalomalacia

Polioencephalomalacia (PEM), which is synonymous with cerebrocortical necrosis (CCN), is a sporadic disorder, most commonly seen in feedlot beef cattle. Signs of PEM include blindness, incoordination, muscle tremors, and possible recumbence with seizures. Two causal factors have been identified and they are probably unrelated. The first is thiamine deficiency, since SARA has been identified as a risk factor for PEM, due to the emergence of bacterial strains that produce increased amounts of thiaminase. The other causal factor is the production of excessive amounts of $H_2S$ in the rumen of animals consuming excessive amounts of sulphur (particularly sulphates) in water, feed, or both. It is recommended that concentrations of $SO_4$ should not exceed 2 mg/kg in the total ration (Gould et al., 1991).

Bloat

Bloat (Ruminal tympany) is abnormal distension of the rumen and reticulum caused by excessive retention of the gases of fermentation, either in the form of a foam mixed with the rumen contents or as free gas separated from the ingesta (Radostits et al., 2007). The main risk factors for pasture bloat are alfalfa, red and white clovers. Bloat can occur at pasture when the proportion of these legumes is high and when cattle are not accustomed to them. The risk of legume bloat decreases with increasing plant maturity due to a decrease in the soluble protein content of the legume. The risk of pasture bloat can be reduced through selection and seeding of pastures with legumes containing relatively high concentrations of condensed tannins (Min et al., 2003). Effective control can be achieved with anti foaming agents, such as glycol surfactant polymers sprayed on to pastures or added to the drinking water (Majak et al., 2005). Alcohol ethoxylate detergents can be incorporated in feed blocks (Stanford et al., 2001).

Bloat can also occur in growing cattle fed high quantities of finely ground grains. The viscosity of the ruminal fluid is increased by the production of an insoluble slime that entraps the gases of fermentation. The prevalence of feedlot bloat can be greatly reduced by incorporating at least 15 % roughage in the diet. Antifoaming agents do not appear to be effective in the control of feedlot bloat (Radostits et al., 2007).

#### 3.5.3.3. Effects of deficiencies of minerals, trace elements and vitamins

New information is added to the text of Section 7.3.4. of the SCAHAW Opinion (2001).

The animals most likely to suffer mineral deficiencies are those kept at pasture for extended periods and without mineral supplements (e.g. adult beef cows). Many pastures are marginal or deficient in phosphorus and selenium. Individual pastures may be absolutely deficient in copper, or contain sufficient molybdenum and sulphur to induce secondary copper deficiency. Rations for growing cattle in intensive and semi-intensive systems are normally supplemented with minerals and trace elements, as deemed necessary. Thus, the risk of disorders associated with mineral deficiencies in fattening beef cattle is low. There has been little significant new research into mineral deficiencies since 2000.

Beef from cattle finished at pasture tends to have higher concentrations of tocopherols, associated with increased vitamin E intake. Increased concentrations of tocopherols and other antioxidants have been linked to improved colour and keeping quality in beef (Wood et al., 2004). Diets for cattle finished in intensive units have been supplemented with vitamin E and selenium, with the primary aim of improving meat quality. There is no convincing evidence to suggest that these supplements have brought improvements in health and welfare.

#### 3.5.3.4. Feeding behaviour and behavioural disorders

New section.

Unnatural foraging regimes, possibly exacerbated by restrictive environments, are thought to elicit stereotypic oral behaviour in cattle, such as tongue-rolling, object-licking, chain-chewing or bar-biting (Bergeron et al., 2006). Possible reasons are sustained feeding motivation (even when the nutritional requirements are met; Redbo and Nordblad, 1997) or an inherent need to forage for a minimum duration of time (Redbo, 1992). Potential beneficial effects on the animals, such as improved gastrointestinal function or general calming effects (Seo et al., 1998), are also discussed. The occurrence of such behaviours is regarded as indicating sub-optimal management conditions and they have clear relevance for welfare (Bergeron et al., 2006). On pasture, stereotypic oral behaviour is not, or only rarely, observed (Redbo, 1992; Ishiwata et al., 2007). Feeding restricted amounts of feed was found to increase the number of cows showing stereotypies (Redbo et al., 1996). In intensively fed beef cattle, the management conditions that likely lead to the development of oral stereotypies are the commonly used high-energy diets with low fibre content (Bergeron et al., 2006). This also applies to corn silage-based diets with finely chopped maize, resulting in a reduced ‘roughage effect’ (less structured fibre). However, there are no studies available on the incidence/prevalence of stereotypic oral behaviour in beef cattle.

#### 3.5.3.5. Undesirable substances in feedstuffs

New information is added to the text of Section 7.3.5. of the SCAHAW Opinion (2001).

Maize silage and, to a lesser extent, grass silage can become contaminated with moulds (e.g. *Fusarium, Aspergillus flavus*) that contain mycotoxins and bacteria, such as *Listeria* and *Clostridium*. Mycotoxins can also be found in grains and oilseeds, although contaminated seeds can be cleaned easily. In general, ruminants are less susceptible to mycointoxication, since the fungi and toxins can be degraded by ruminal microorganisms. Animals experiencing a mycotoxicosis may exhibit a few or many of a variety of clinical signs, including: digestive disorders, reduced feed consumption, unthriftiness, rough hair coat, undernourished appearance, low production, poor production efficiency, impaired reproduction and/or a mixed infectious disease profile. Mycotoxins can increase the incidence of disease and reduce production efficiency. Some of the signs observed with mycotoxicosis may therefore be secondary, resulting from an opportunistic disease, which is present because of mycotoxin-induced immune suppression. Immunotoxic effects of mycotoxins have been reviewed by Bondy and Pestka (2000) and Oswald et al. (2005).

#### 3.5.3.6. Interaction between environment and feeding

New section.

Heat exchanges of beef cattle, as well as the problems and alleviation of heat and cold stress, have been reviewed in Section 3.4.1 of this Opinion. In essence, maintenance of homeothermy involves the dissipation of heat produced in metabolism to the environment by two mechanisms: sensible means (convection, conduction, radiation) across a temperature gradient from the body core to the air and insensible means (i.e. evaporation of moisture from the skin and respiratory tract). The amount of metabolic heat produced by an animal increases with increasing ME intake. The ME requirement for maintenance of beef steers ($ME_m$ Heat production (H) at maintenance) is approximately 450kJ/kg$^{0.75}$ per 24h. For bulls the value is closer to 500 kJ/kg$^{0.75}$ per 24h. The ME intake of rapidly growing beef cattle consuming highly metabolisable feed can approach 2.5 $ME_m$. The net efficiency of utilisation of ME for growth in beef cattle ($k_m$) ranges from approximately 0.4 to 0.6 in direct proportion to the metabolisability of the feed. For a feed with a $k_m$ of 0.6, 40 % of ME consumed above maintenance will be dissipated as heat. Thus, for a growing beef bull consuming 1250 kJME/kg$^{0.75}$ per 24 h, the estimated heat production will be 800 kJ/kg$^{0.75}$ per 24 h (500 + (0.4 x 750)), which is approximately 1.8 times that of a mature cow at maintenance (800/450; Alderman and Cottrill, 1993).

It follows from these core facts of heat exchange that cattle with the highest metabolic rates (i.e. rapidly growing beef cattle with high ME intakes) are potentially most susceptible to heat stress and most resistant to cold stress. Moreover, metabolic rate is proportional to body weight, kg$^{0.75}$, which corresponds approximately to surface area. Thus, in a rapidly growing bull calf weighing 200 kg, H will be much greater per unit of surface area than compared to its mother and, accordingly, it will be more cold tolerant and heat sensitive.

Beef cattle in open feedlots consuming high energy rations *ad libitum* can sustain optimal growth rates through the coldest months of the winter, provided that they have sufficient shelter from rain and precipitation. Reports of reduced weight gains in mid winter appear to be linked to reduced feed intake at times of short day length (Webster, 1974). Strategies for maximising the feed conversion efficiency of beef cattle in cold environments include providing the bulk of feed in the evening before the coldest period of the 24 h. Bergen et al. (2008) showed that this was effective in the coldest periods and for younger animals. It had no significant effects on the late finishing period, presumably because the animals were not cold at this time. However, with the spring thaw, open feedlots in North America can become a sea of mud. In these circumstances, weight gains are, unsurprisingly, reduced in cattle that are chilled, filthy and reluctant to approach the feed bunks.

One of the most effective ways for an animal to reduce heat stress is to reduce ME intake and thereby H. However, this is inconsistent with high rates of weight gain. *Bos indicus* cattle can maintain feed intake and fat reserves in response to heat stress better than *Bos taurus* cattle (Beatty et al., 2006). The ME intake and weight gain of rapidly growing beef cattle can be increased during hot periods by providing most feed in the relative cool of the evening, or by increasing the concentrate:roughage ratio, thereby increasing $k_f$ and so reducing metabolic heat production (Arias et al., 2011).

***Conclusions***

1. Addition to Conclusion 3. of Section 7.3 of the SCAHAW Opinion (2001; see UC.16 in the Conclusions and Recommendations section): Bloat can also occur in growing cattle fed high quantities of finely ground grains. The prevalence of feedlot bloat can be greatly reduced by incorporating at least 15 % roughage in the diet.

2. Beef cattle fed intensively on high grain rations (< 15 % physically effective fibre) are at a high risk of digestive disorders, especially sub-acute ruminal acidosis (SARA). Cattle that experience repeated episodes of SARA are at risk of rumen parakeratosis, liver abscesses and laminitis. Measures for the control of SARA include the feeding of buffers, drugs to stimulate salivation and antibiotics (e.g. tylosin, monensin).

3. Addition to Conclusion 8. of Section section 7.3 of the SCAHAW Opinion (2001; see UC.18 in the Conclusions and Recommendations section): Poorly conserved silage may be a source of mycotoxins, and pathogenic bacteria such as *Listeria* and *Clostridium* spp.

4. Addition to Conclusion 6. of Section 5. of the SCAHAW Opinion (2001; see UC.2 in the Conclusions and Recommendations section): Rumination time is primarily determined by the quantity of long fibre in the diet and, when diets are lacking in long fibres, normal rumination and salivation are greatly reduced and can lead to digestive disorders.

***Recommendations***

1. In order to meet the needs of beef cattle in relation to physiology, health and behaviour, the feed should satisfy four essential criteria: provision of adequate and balanced amounts of ME and all other essential nutrients, as required for maintenance, activity, reproduction and growth; provision of feed of a physical and chemical composition consistent with stable fermentation in the reticulo-rumen and healthy digestion in the gastro-intestinal tract; provision of feed in a form that provides oral satisfaction (e.g. rumination) and does not predispose to stereotypic behaviour; provision of feed that does no harm.

2. Rations for finishing cattle should include at least 15 % physically effective fibre in order to reduce the risk of bloat, SARA and its sequelae. Feed supplements for the control of SARA should be restricted to those that stabilise rumen pH through natural buffering, rather than the selective manipulation of rumen microorganisms.

### 3.5.4. Grouping of animals

#### 3.5.4.1. Group size

No critical new information to be added to Section 7.4.1. of the SCAHAW Opinion (2001).

#### 3.5.4.2. Mixing of groups

Data from Section 7.4.2. of the previous Opinion (SCAHAW, 2001) is supported by new research, and new information is added.

Steers responded to regrouping with increased plasma cortisol, albumin, urea and NEFA, but immune measurements were unchanged (Gupta et al., 2005). In terms of maintenance behaviour following regrouping, steers were more active (standing, eating, drinking) but showed no difference in head-to-head behaviour (Gupta et al., 2008). However, in heifers, there was no habituation in terms of elicitation of agonistic interactions after regrouping (Raussi et al., 2005). After mixing, agonistic behaviours were more frequent in homogenous groups of bulls (in terms of weight) than in more heterogeneous groups (Mounier et al., 2005). This also led to more cohesive behaviours in a food competition test, less fear responses during separation and lower cortisol levels during pre-slaughter handling (Mounier et al., 2006) in the unmixed groups, whilst homogeneity of body weight could not be maintained throughout the finishing period (Mounier et al., 2005). From a health perspective, mixing of animals has disadvantages compared to all-in all-out systems as this may prolong disease outbreaks and increase the exposure to pathogens. A field study also suggested that unmixed bulls grew faster than bulls mixed at the beginning of the finishing period (Mounier et al., 2006).

#### 3.5.4.3. Buller steer syndrome

Some new information is added to the text of Section 7.4.3. of the SCAHAW Opinion (2001).

In a study in Canadian feedlots, it was shown that bullers were 2.5 times more susceptible to disease and 3.2 times more likely to die (Taylor et al., 1997).

As already reported in SCAHAW (2001), electrified grids above the animals are used to reduce mounting but may cause disturbance to the animals. Similar effects may be achieved by solid bars placed above the animals. However, such bars have also been reported to increase bruising if set too low (< 20 cm above the withers of the animals; von Holleben et al., 2003).

***Conclusions***

1. Mixing and regrouping of cattle increase the incidence of agonistic behaviours and also have disadvantages from a health perspective. Older and more aggressive animals may cause trauma and continuous and severe stress to lower ranking calves (bullers). Small and young animals are more prone to disease if kept with larger and older animals. Young heifers may be harassed and become pregnant when kept with sexually mature bulls.

2. Solid bars or electrified grids are sometimes used for curbing the mounting activities of bulls at high stocking densities but cause disturbance to the animals.

***Recommendations***

1. Groups should be made up with animals of similar age, weight and sex.

2. Care should be taken to identify and remove buller animals from groups where they are subject to attacks.

### 3.5.5. Weaning

#### 3.5.5.1. Weaning consequences

No critical new information to be added to Section 7.5.1. of the SCAHAW Opinion (2001).

#### 3.5.5.2. Early weaning of suckled calves

No critical new information to be added to Section 7.5.2. of the SCAHAW Opinion (2001).

#### 3.5.5.3. Preconditioning

No critical new information to be added to Section 7.5.3. of the SCAHAW Opinion (2001).

#### 3.5.5.4. Effect of different post-weaning management on weight gain

No critical new information to be added to Section 7.5.4. of the SCAHAW Opinion (2001).

#### 3.5.5.5. Effect of different post-weaning management on health

No critical new information to be added to Section 7.5.5. of the SCAHAW Opinion (2001).

#### 3.5.5.6. Effect of weaning on cow-calf attachment

Some new information is added to the text of Section 7.5.6. of the SCAHAW Opinion (2001).

Weaning of calves is traditionally undertaken by an abrupt separation of mother and calf. This generally results in the display of distress signals by the calves during the first days after separation. For instance, an increase in vocalisations and locomotion is typically seen (Newberry and Swanson, 2008), and physiological indicators of stress, such as adrenal responses, have been demonstrated (Lefcourt and Elsasser, 1995; Hickey et al., 2003), as well as behavioural indications of stress, such as social behaviour changes (Vessier and Le Neindre, 1989; Price et al., 2003b; Haley et al., 2005). These effects are thought to be caused by a disturbance in the mother-young bonding (Newberry and Swanson, 2008; Weary et al., 2008) and the loss of milk supply (Ungerfeld et al., 2009).

Strategies to reduce weaning stress (compared to abrupt weaning) aim at mimicking the natural weaning process by using nose plates that prevent nursing but allow ingesting solid food while the calf is still with the dam or by separating the cows and calves through a fence before final separation (Enriquez et al., 2011). Studies assessing these methods have provided conflicting results. For example, weaning Hereford or Hereford x Angus 180 day-old beef calves in three different ways: 1) weaned abruptly on day 0 (CON), 2) separating calves from dams by a fenceline 17 days before actual weaning but kept in visual sight (FEN), or 3) keeping cows and calves together but inserting a nose flap in the nose of the calves (NF), has resulted in FEN calves vocalising more than CON and NF calves, with CON calves showing more play behaviour and rumination than FEN and NF calves, as well as CON calves having a higher daily weight gain (Enriquez et al., 2010).

On the other hand, two-stage weaning using nose-flaps resulted in less vocalisations, less walking, more eating and more resting than in control calves, while average daily gain was not affected (Haley et al., 2005). Similarly, fenceline weaning reduced behavioural indicators of distress and daily weight gain was higher in fenceline contact calves than in abruptly weaned calves (Price et al., 2003b).

***Conclusions***

1. It remains unclear whether two-stage weaning methods for calves of approximately 180 days of age, such as fenceline contact or the use of nose flaps, actually provide better welfare for the calves as compared with immediate total separation.

***Recommendations***

1. More research into the welfare benefits of two-stage versus abrupt weaning methods of calves from suckler herds should be carried out.

### 3.5.6. Human-animal interaction

#### 3.5.6.1. Human-cattle interactions in modern husbandry systems

Some new information is added to the text of Section 7.6.1. of the SCAHAW Opinion (2001).

Changes in housing have occurred, especially during winter. Together with increasing herd sizes and mechanisation, tie-stall systems, which imply many human contacts, have become much less common. Nowadays, more and more animals live free in loose stable or outdoors with limited human contacts. The changes in husbandry practices described above have acted to decrease the animals' familiarity to humans and to increase their perception of humans as a potential danger. In these situations, fear reactions and antipredatory strategies, such as flight or fight, are typically observed during handling (Waiblinger et al., 2006).

#### 3.5.6.2. Factors influencing the stress reaction during handling

Recent research has reinforced some of the conclusions included in Section 7.6.2. of the SCAHAW Opinion (2001).

Recent studies have confirmed earlier work that humans express more or less positive and negative interaction with animals according to their attitude towards the animals (e.g. Waiblinger et al., 2002). In a field study with French beef farmers, positive attitudes towards animals were linked with positive attitudes towards contact with animals, whereas no such correlations existed with attitudes towards negative handling of animals (Boivin et al., 2007). Earlier studies, already reported in the previous Opinion (SCAHAW, 2001), have shown that human contact during the first few days following weaning appeared more efficient and durable than the same procedure performed 6 weeks later. This was confirmed in a study where contact with humans, especially during the first 4 days of life, increased the motivation of calves to approach humans (Krohn et al., 2001). In Salers calves, this effect did not depend on the duration of additional human contact at an early age, but was shown to occur only in calves born to docile dams (Boivin et al., 2009).

More recent studies have shown that the presence of the dam may limit the effect of handling treatment on the motivation of calves to interact with humans (Krohn et al., 2003). This was interpreted as the dam preventing the secondary socialisation of calves with humans.

By comparing individually and pairwise housed calves, Lensink et al. (2001) found that the latter needed more time to get into contact with a test person and had less frequent contacts, and it took more time to load them on a truck. Additional contact calves on the other hand interacted longer with a test person, showed less withdrawal responses, were easier to load and had lower heart rates during transport.

Methods for assessing the human-animal relationship have been reviewed by Waiblinger et al. (2006). For beef cattle, avoidance distance testing at the feed bunk appears to be promising. It has been shown to be reliably assessed (Windschnurer et al., 2009) and to work for singly- and group-housed animals (Mazurek et al., 2011). Furthermore, results were not influenced by the dominant or the flightiest animal.

***Conclusions***

1. Addition to Conclusion 1. of Section 7.6. of the SCAHAW Opinion (2001; see UC.21 in the Conclusions and Recommendations section): Human contact during the first days of life appears to be most effective in terms of reducing fear of humans compared to later periods. Factors such as breed, temperament or presence of the dam may limit the effect of handling treatment. The testing of avoidance at the feeding site appears to be a promising measure of human-animal relationship in beef cattle.

***Recommendations***

1. Addition to Recommendation 2. of Section 7.6. of the SCAHAW Opinion (2001; see UR.12 in the Conclusions and Recommendations section): Handling facilities for fattening beef cattle should be designed in such a way as to minimise the need for direct contact between handler and animal, so as to limit stress for the animal and risk of injury to the handler.

2. The effects of group size on the quality of human-cattle interactions should be further studied.

### 3.5.7. Disease management issues

No critical new information to be added to Section 7.7. of the SCAHAW Opinion (2001).

#### 3.5.7.1. Disease of animals at pasture

New section.

Beef animals kept on pasture are exposed to very specific pathogens and disease factors. These were not addressed in the previous reports so they have been added in this revision.

Many of the diseases presented are a minor problem for animals at pasture when food and water are available in adequate quantity and quality because there is usually a balance between the immune system and the infectious agent. In case of droughts, heavy snow and very cold conditions, inanition and thirst will immunocompromise animals to the stage of resistance break, disease and possibly death. Additionally, a reduced feed intake may result in fatty infiltration and degeneration of the liver, leading to an increased susceptibility to some poisons, reduction in resistance to infection and high mortality (Radostits et al., 2007). Supplementation is usually initiated to address these problems, but in many cases it is too late or not available to all cattle in sufficient quantities. In some regions, supplementation usually consists of poor-quality grass hay or cereal grain straw and very little grain or concentrate - the lack of a protein source will eventually lead to the death of rumen microorganisms, rumen and abomasal impactation, anasarca, weakness and death. Some local breeds (autochthones) are more resistant to underfeeding, toxins and diseases and should be preferred where extreme environmental conditions are to be expected.

Internal (helminths) and external (ticks, mites, lice, flies, bots, etc.) parasite infestations are very common in beef cattle at pasture and may cause weight loss, anaemia, hair and skin damage, infectious disease (acting as vectors or secondary), reduced immunity, diarrhoea, and pneumonia, among others (Radostits et al., 2007). However, most gastro-intestinal parasites will stimulate an effective level of protective immunity in healthy and well-fed animals at pasture. A prolonged susceptibility to reinfection is the reason why *Ostertagia* sp. is considered the most economically important gastro-intestinal nematode in temperate regions of the world (Gasbarre et al., 2001).

Animals kept at pasture are usually exposed to parasite infestation that can affect welfare. It is essential to control most of these parasites and reduce the adverse effects based on monitoring and the use of, for example, oral or injectable antiparasitic drugs. Pasture rotation has also shown promising results (Larsson et al., 2006).

The haemoparasites *Babesia bovis*, *Anaplasma marginale* and *Theileria* sp. are extremely important pathogens of cattle at pasture in the south of Europe. They cause anaemia and death especially when animals are exposed to adverse environmental conditions. Effective tick control is essential for the prevention of these diseases.

Diarrhoea is the most common cause of calf mortality in beef herds. *Cryptosporidium parvum* and other coccidae from contaminated water are important contributors to diarrhoea outbreaks in calves, and *Clostridium* sp. spores in pastures can also cause heavy losses in different acute toxic syndromes depending on the *Clostridium* sp. causing the infection. The incidence of diarrhoea may vary according to herd size. Slavik et al. (2009) found an incidence of diarrhoea of 12.1 % and 6.7 % in small and large herds, respectively. An epidemiological survey of calf losses in free range and suckling cow herds showed that the percentage of calf losses increased with herd size - 97 % of herds with less than 20 suckling cows had a calf mortality of less than 10 %, but in herds with more than 300 cows calf losses were higher than 10 % The main causes of death were infections or infestations manifested as pathology of the digestive (50 %) and respiratory tracts (38 %). The authors calculated that the disease risk for calves born from cows that were housed during the calving season was 2.45 times higher compared with cows kept the whole year on free-range (Laiblin et al., 1996).

Several other diseases that affect animals at pasture (e.g. *Leptospira* in stagnant water, botulism from dead animals at water sources, IBR and BVD-MD from bought-in cattle) can be controlled through biosecurity, good management, vaccination and eradication or control programmes. Diarrhoea and deaths can also be caused by outbreaks of *Salmonella* spp. (Smith, 2002; Mohler et al., 2009).

Animals at pasture are particularly exposed to toxic plants and the ingestion of these can cause massive deaths or very sick animals. Most toxic plants are unpalatable, and they only become a problem for livestock when alternative forages are unavailable, or when they are included in hay and other harvested feeds (Stegelmeier, 2011). Also, exotic plants may cause problems because animals are not prepared to avoid them. Close inspection of feed (e.g. hay), as well as preventing hunger through supplementation and eliminating undesirable plants from pastures through species-specific herbicide are recommended (Stegelmeier, 2011). Photodynamic agents in certain plants may cause primary photosensitisation, which results in damage of non-pigmented skin in cattle exposed to direct sunlight.

Sorghum-sudan hays are frequently fed and sometimes contain high nitrate concentrations if produced with high levels of nitrogen fertilisation and harvested immediately after or during stressful growing conditions, such as hot droughty weather. Nitrates will be reduced to nitrites by rumen microorganisms, potentially leading to weakness, hypoxia, abortion, convulsions and death (Swann, 1975; Suttle, 2010).

Water

In general, cattle health problems are not caused by poor water quality, but by stress resulting from lack of water or from unpalatable water with high levels of dissolved substances (Morgan, 2011). However, free running water, wells and other sources can be heavily contaminated with chemical pollutants. Cattle in extensive systems are more exposed to these threats. Polioencephalomalacia may occur from sulphur in drinking water, particularly during droughts, as the sulphate becomes more concentrated, and in hot weather as cattle consume more water. Nitrate and nitrite contamination of water can result in death and/or abortion in ruminants. Other potential hazardous pollutants are heavy metals (lead, copper, cadmium, etc.) that may have industrial, commercial or even agricultural origin and are made available to cattle through water (Suttle, 2010; Morgan, 2011).

Contact with wildlife

Animals at pasture are particularly exposed to wildlife (deer, badger, wild-boar, and others) and consequentially to potential carriers of pathogens. Tuberculosis, brucellosis, Johne’s disease, rabies and various parasites are only a few examples (Gondim, 2006; Blancou, 2008; Pappas, 2010; Corner et al., 2011).

#### 3.5.7.2. Disease in fattening units

New section.

Despite advances in vaccine and antimicrobial technology, morbidity and mortality rates in fattening units have not declined (Edwards, 2010). Data from the USA (Loneragan et al., 2001) have shown a constant increase in number of deaths per 1,000 animals: 10.3 (1994), 14.2 (1996), and 17.5 (2003).

The factors involved in this high incidence of disease will be addressed in detail but they can be summarised as: stress, due to co-mingling, transport, weaning, mutilations, overstocking and human handling; environmental factors, such as gases (ammonia), dust, high temperature/humidity, insects; genetics that affect temperament and susceptibility to different diseases; and infectious agents (virus and bacteria).

Over the years, it has been made clear that managing for a single disease-causing agent or risk factor does not eliminate disease from the population (Thomson and White, 2006). Adequate disease control and prevention need to be addressed to most if not all of these issues, and biosecurity measures are essential.

Bovine respiratory disease

Cattle are susceptible to a variety of respiratory pathogens because of anatomical and physiological factors. These handicaps and the conditions in which some cattle are raised lead to respiratory infections being common and they are sometimes summarised under the name Bovine Respiratory Disease (BRD), which is considered to be one of the most important welfare challenges in beef production (Taylor et al., 2010; Schaefer et al., 2011).

Respiratory disease is the main cause of morbidity (70-80 % of total disease incidence) and mortality (40-50 % of total mortality) of calves in feedlots but it is also often undetected at sub-clinical levels or is under-diagnosed (Edwards, 2010). Schneider et al. (2009) showed that the incidence of clinical BRD was 8.17 %, but lung lesions at slaughter were present in 61.9 % of cattle. Wittum et al. (1996) found that 68 % of untreated cattle had pulmonary lesions.

BRD has enormous economic and welfare impact in the beef production industry. Twenty additional days on feed were required for beef heifers treated three times for BRD to have similar body-weight compared with untreated heifers (Holland et al., 2010). Snowder et al. (2006) calculated that the economic loss associated with lower gains and treatment costs for BRD infection in a 1,000-cattle feedlot was over $13.90 per animal, not including labour and associated handling costs. Annual losses due to BRD in the USA are calculated to be over $3 billion per year (Watts and Sweeney, 2010).

BRD can evolve as a peracute, acute or chronic disease and all of these stages cause very poor welfare, which is demonstrated by signs of discomfort and pain, dyspnoea and open mouth breathing, weakness, debilitation, isolation from the herd, reduced appetite and weight loss. BRD, if not treated early, will cause irreversible damage to the lung, leading to chronic pneumonia and a substantial reduction in weight gain. Chronically affected animals may survive until slaughter but will show very poor body condition, constant coughing, painful breathing and muscular weakness. Post-mortem lesions include extensive lung consolidation, pleura adhesions, bronchiectasis and abscess formation (Fulton et al., 2009; Panciera and Confer, 2010). These animals are a source of exposure and infection in the herd. They are constantly in pain and distress, and are incurable and uneconomical even after prolonged antimicrobial treatments (George Stilwell, FMV-UTL, personal communication, January 2012).

The most common bacterial pathogens involved with the BRD complex include: *Mannheimia haemolytica*, *Pasteurella multocida*, *Histophilus somni* and *Mycoplasma bovis* (Welsh et al., 2004; Booker et al., 2008; Griffin et al., 2010). All of these pathogens are normal inhabitants of the upper respiratory tract (Callan and Garry, 2002; Griffin et al., 2010) but environmental and host factors (e.g. stress) usually affect the immunity of animals brought in for fattening, allowing bacteria access to the lung, resulting in pulmonary compromise, inflammation, extensive lesions and respiratory insufficiency (Confer, 2009). In addition, several viral pathogens, such as IBR, BVDV, parainfluenza-3 (PI3), and bovine respiratory syncytial virus (BRSV) are involved in the BRD complex and may cause respiratory disease by themselves or in synergy with (or predisposing to) the above mentioned bacteria (Stilwell et al., 2008c; Brodersen, 2010; Edwards, 2010; Panciera and Confer, 2010). *M. haemolytica* (peracute and acute cases) and *M. bovis* (chronic cases) were the most common agents found in feedlot animals (Booker et al., 2008). The pathogens and the disease involved are also described in Section 4.3.9.3.

The most important environmental factors involved in BRD are extreme temperatures and humidity (> 78 % relative humidity), stocking density and presence of ammonia and other gases due to lack of ventilation. A twofold increase in stocking density requires nearly a tenfold increase in ventilation capacity to maintain pathogenic bacteria levels at similar concentrations (Wathes et al., 1983). Thus, stocking density is the major factor determining the concentration of airborne bacteria and risk of respiratory morbidity (Gorden and Plummer, 2010).

Immunosuppression is mainly the result of potentially additive stress factors, such as weaning, transportation, mutilations, hierarchy establishment at co-mingling, diet changes, human handling and many others (Edwards, 2010; Taylor et al., 2010). Castration of calves on arrival at the feedlot decreases performance (average daily gain) and increases morbidity (Thomson and White, 2006). Males castrated before entering the feedlot were more likely to become ill with BRD than heifers in the same conditions (Snowder et al., 2006). Pregnant heifers were more susceptible to disease when kept in feedlots (Buhman et al., 2003).

Colostrum-deprived calves have proven to be more prone to BRD and other diseases (Dewell et al., 2006; Ackermann et al., 2010; Stilwell and Campos de Carvalho, 2011). It has also been demonstrated that stressed calves, nervous animals and some breeds are more susceptible to BRD (Fell et al., 1999; Snowder et al., 2006; Cusack et al., 2007; Stilwell et al., 2008c; Pereira and Stilwell, 2011). Resistance to BRD also has a genetic component, although heritability seems to be small (Schneider et al., 2010). “Bullers” (hierarchal lower animals that are constantly harassed by pen mates) are 2.5 times more likely to have respiratory disease and 3.2 times more likely to die (Taylor et al., 1999, 2010). Animal weight when entering the feedlot is also a significant factor (Thomson and White, 2006) and co-mingling animals of different ages and size will predispose to BRD those that are smaller.

Genomics opportunities for increasing resistance to pathogen-induced diseases are presented in the Genetics Section (3.5.2.).

A different kind of respiratory disease affecting feedlot cattle is grouped as "interstitial pneumonia" (IP) and is characterised by acute pulmonary oedema and emphysema (Fulton et al., 2009). The acute form causes severe respiratory distress that can lead to asphyxiation and death. Chronic cases are usually complicated by bacterial infection following an evolution as described above. The aetiology of IP is variable and not well understood but may include toxins, allergens, fungi found in mouldy hay, noxious gases, viruses and parasites (Doster, 2010).

<u>Other diseases in beef cattle</u>

Bloat and ruminal acidosis are dealt with in Section 3.5.3.2. of this Opinion.

Diarrhoea caused by coccidiae (*Eimeria* sp. and others) is common in cattle kept in overcrowded, stressful or poor hygienic conditions (Bowman, 1999). It usually affects cattle indoors but in some circumstances may cause diarrhoea in calves at pasture. Older cattle are usually less susceptible to coccidiosis than younger cattle. As production units become larger and more intensive the incidence of coccidiosis increases (Step et al., 2002). Clinical signs include bloody diarrhoea, dehydration, weight loss, anaemia and sometimes death. Several drugs are used for the treatment and prevention of this disease.

), or pink eye, was not addressed in the previous report, although it is a cause of very poor welfare. It is a common eye disease, particularly during hot weather (summer and autumn), caused by a Gram-negative bacteria (*Moraxella bovis*), with dust and viruses acting as predisposing factors and face flies (*Musca autumnalis*) as vectors. The clinical signs may vary from mild conjunctivitis with blepharospasm to severe damage of the eye including rupture of the cornea. It is an important cause of poor welfare due to pain, fever, distress, discomfort and weight loss (Crispin, 2005). Some calves will become blind (uni- or bi-lateral) if not treated early, and healthy animals can act as carriers (Van Halderen and Henton, 2004). Treatment is achieved with topical or systemic antibiotics but because it is a painful condition an analgesic drug should be given. Some antimicrobial drugs (e.g. oxytetracycline) should not be injected sub-conjunctivally because of tissue reaction, discomfort and pain (Van Halderen and Henton, 2004; George Stilwell, FMV-UTL, personal communication, January 2012). Vaccination (of dam or calves at risk) is possible in some countries but is not very efficient. Calves that received colostrum from vaccinated dams were more resistant to IBK than calves from non-vaccinated dams after challenge with *M. bovis* (Step and Smith, 2006). Insect control is essential for the control of outbreaks.

#### 3.5.7.3. Diagnosis and human influence on morbidity and mortality

New information is added to the text of Section 7.7.1. of the SCAHAW Opinion (2001).

Many feedlot health problems can be attributed to errors in management (Radostits, 2001). In beef production, the caretaker generally spends only short periods with the animals. Regular human-animal interactions occur mainly during food distribution, which, however, does not include direct contact between the stockperson and the animals. Observation of the animals is particularly important as problems are likely to be expressed through animal behaviour, although many stockpersons do not recognise early signs of respiratory disease (Sivula et al., 1996; Gorden and Plummer, 2010).

As described above, diagnosis of BRD-affected calves through clinical signs is not easy or reliable when coughing and tachypnea are absent. This is particularly true in pens where a large number of animals are kept. Therefore, regular, patient and careful observations of the animals are required in order to detect signs of disease at an early stage. The diagnosis of diseases and disorders of fattening cattle can be difficult to carry out for both the farmer and the veterinarian. In order to perform clinical examinations, animals showing disease signs have to be separated from the group and restrained before examination for reasons of thoroughness, as well as human safety. Increased rectal temperature (above 39.5 °C) is conventionally used to detect and select animals for treatment at admission to the feedlot. However, this method has been shown to have a very low sensitivity as many animals, even in the acute stage of the disease, will have "normal" rectal temperature. Clinical signs of BRD include coughing, tachypnea, isolation, nasal discharge and “droopy ear”, but the diagnostic sensitivity and specificity of clinical examination were 61.8 % and 62.8 %, respectively, in a retrospective study (White and Renter, 2009). Reduced feed intake and reduced growth of the animals, which may also indicate disease, are difficult to assess without regular weighing, or may only be apparent when the disease process has advanced. The use of a screening system that evaluates rectal temperature, nasal discharge, cough and ocular discharge, and ear position has been developed and may help to assign an individual respiratory severity score for each calf (McGuirk, 2008). Researchers from Wisconsin (UW) School of Veterinary Medicine indicated that, if used correctly, more than 85 % of calves that need to be treated for BRD should be correctly identified by calf caretakers.

New methods for early identification of sick animals are becoming available. In a study using a reticulo-rumen bolus (Timsit et al., 2011), which allowed continuous measurement and recording of reticulo-rumen temperature, it was found that fever episodes began 4 to 177 h (mean = 50 h) before BRD treatment. Schaefer et al. (2007) demonstrated that infrared thermography identified calves at early stages of illness, often several days to more than one week before clinical signs were seen. Automated collection of infrared thermography data around the water troughs was efficient in identifying true positive and true negative BRD-affected calves (Schaefer et al., 2011).

#### 3.5.7.4. Use of antimicrobials and other therapeutic strategies

New information is added to the text of Section 7.7.2. of the SCAHAW Opinion (2001).

Increasing mortality is the result of multiple factors, but it does suggest that the advent of new antimicrobial agents has not eliminated cattle death caused by infectious organisms (Thomson and White, 2006). This means that, although treatment is an important issue for the sake of the individual animal’s welfare, it should not be a priority in beef cattle disease management.

Selection of a therapeutic agent should be based on isolated or suspected aetiologic agents based on previous experience with the herd and sensitivity testing. For this reason, good records regarding previous outbreaks and laboratory results should be kept on each farm. When this is not achievable a thorough clinical history and examination should be made to decide which pathogen is more likely to cause the disease. Material from broncho-alveolar lavage, nasal swabs and post-mortem examinations should be regularly sent for microbial identification and antimicrobial sensitivity testing, and dead animals should be autopsied regularly.

The regimes for the use of antimicrobials in beef cattle are often called prophylaxis, metaphylaxis and therapeutics.

<u>Prophylactic</u> use means administration of antimicrobials to all animals in a group before they show signs of disease. This use usually occurs at stages of the production where, based on previous experiences, there is an increased risk of various diseases, in particular at the beginning of the fattening period. Several studies have shown a reduction in morbidity and mortality when animals are treated on arrival (Daniels et al., 2000; Frank et al., 2002; Macartney et al., 2003). A reduction in mortality and morbidity (of 2 % and 26 %, respectively) in animals that received antimicrobial treatment on arrival at the feedlot was shown in a recent meta-analysis. Daily weight gain was 0.11 kg higher in these animals in comparison with calves not receiving treatment (Wileman et al., 2009). While the prophylactic use of veterinary products may be seen, especially from the farmer’s point of view, as a contribution to animal health, it may also serve to conceal deficits in housing conditions and farm management.

<u>Metaphylaxis</u> involves the therapeutic use of antimicrobials which, for practical and epidemiological reasons, are given to all animals in a group when some animals (usually above 10 %) show clinical signs of the disease during a short period of time. This method has proven to reduce BRD in feedlots mainly due to the difficulty in diagnosing all affected animals. However, Galyean et al. (1995) showed no difference in BRD incidence when only animals with a rectal temperature above 39.5 °C were treated compared with the full treatment approach.

Therapeutic use is defined as the administration of antimicrobials only to animals that show clinical signs of disease.

The above three regimes for the use of antimicrobials have also been applied for other veterinary drugs.

Studies have shown that stress will cause an increase in shedding and circulation of pathogens and this can explain why the prevalence of these bacteria is higher after transport and co-mingling (Sato et al., 2005).

As found in other animal species, the use of antimicrobials results in an increased prevalence of antibiotic resistant bacteria when used in beef cattle. However, a recent European study (Hendriksen et al., 2008) has shown that the number of *M. haemolytica* and *P. multocida* strains resistant to antimicrobials is low, except for tetracycline administration (40 to 50 % in France and Portugal).

Long acting preparations are now available that reduce the need for frequent handling and restraint of sick and stressed calves. This reduces manpower, additional stress, probability of antimicrobial sub-dosage, and misuse and negligent failure to follow up the treatment.

When oedema and inflammation reaction are severe, as in *M. haemolytica* infections, irreversible damage to the lung can only be avoided by simultaneous control of bacterial infection and local inflammation. In these cases, the use of non-steroidal anti-inflammatory drugs (NSAIDs) is considered essential for the treatment of BRD-affected calves (Lekeux, 2007; Guzel et al., 2010; Lekeux and Wallemacq, 2010). An additional benefit is the reduction of fever, pain and discomfort, which leads to improved food intake and welfare (Lockwood et al., 2003).

Dehydration and electrolyte imbalance is not limited to cases of diarrhoea and fluid therapy is sometimes essential for the recuperation of calves affected by BRD, ruminal acidosis and other diseases.

#### 3.5.7.5. Disease prevention

New section.

The objective of preconditioning is to prepare the weaned calf for the feedlot environment by subjecting it to the stress of weaning, vaccination, mutilations and other common processing procedures well in advance of its entering the feedlot. Weaning and conditioning at the suckler farm some time before transporting and co-mingling separates these two types of stressors, resulting in healthier calves. For example, castration at the suckler farm compared with at the feedlot has been shown to reduce BRD incidence and improve weight gain (Bretschneider, 2005; Ratcliff et al., 2005). Several value-added calves' programmes exist in the USA by which calves are sold at a higher price when they have been preconditioned. The preconditioning programme will be successful only if both the calf producer and the feedlot operator benefit.

It has been shown that the shedding of pathogens via respiratory secretions is very high in the early phases of respiratory disease and this can happen soon after entering fattening units (Fulton et al., 2009). Since sick animals can expose an entire pen of animals to various pathogens, either by simple close contact or by environmental contamination, care in co-mingling animals from different sources is considered sound management. The best way to limit pathogen spread by contact is to avoid the introduction of new animals to closed herds or pens of cattle, but if this is not possible quarantine could play a role in reducing the spread of respiratory and other diseases when new animals are introduced. The duration of viral respiratory pathogen shedding has been shown to occur for 14 days after infection but may persist longer in individual animals, which suggests that quarantine for approximately 14 to 21 days is advisable (Barrington et al., 2002; Callan and Garry, 2002). Convalescent calves should be separated from other animals until after the shedding of pathogens has decreased to minimal levels or for at least 3 weeks (Barrington et al., 2002). In summary, quarantine of incoming livestock, maintenance of hospital areas that do not allow contact with healthy animals and prevention of animal contact between different age groups of cattle are good biosecurity measures for beef cattle.

However, it should be said that quarantine may not be effective against diseases with chronic carrier states, such as in the case of Johne's disease (Callan and Garry, 2002).

Many studies have looked at the efficacy of vaccination on the prevalence of BRD. However, the results are contradictory mainly because BRD results from many other factors besides the involvement of viruses or bacteria. Overall, the studies indicate that vaccination will only reduce BRD incidence when carried out in healthy animals and prior to the exposure to the deleterious environmental and stressful factors, such as weaning, marketing, transportation, extreme temperatures, and inadequate ventilation.

Vitamin E in feed or drench when entering the feedlot is the only nutritional supplement that seems beneficial for decreasing BRD morbidity (Duff and Galyean, 2007)

In case of a high incidence of bloat and ruminal acidosis, diet formulation and management should be reviewed and fibre proportion increased (Radostits et al., 2007).

For more details see Section 4.3.11 of this Opinion (Control and management of diseases in calves).

***Conclusions***

1. Most beef cattle diseases have a multi-factorial aetiology. In addition to pathogens and animal-related conditions, other contributing factors include stocking density and environmental stressors that disturb homeostasis in the animal.

2. Chronic infections usually arise when animals are not detected and treated early in the course of disease. Chronic pneumonias cause very poor welfare with pain, asphyxiation and ill-thrift.

3. Preconditioning has shown to be a sound and efficient management procedure that is associated with reduced morbidity and mortality.

***Recommendations***

1. Addition to Recommendation 7. of Section 6 of the SCAHAW Opinion (2001; see UR.2 in Conclusions and Recommendations section): Farms regularly receiving animals from different origins should have quarantine facilities and quarantine duration for in-coming animals should be at least 14 days.

2. Addition to Recommendation 1. of Section 7.7 of the SCAHAW Opinion (2001; see UR.13 in Conclusions and Recommendations section): To promote effective control of multi-factorial infectious diseases cattle should be kept in environments that minimise physiological and emotional stress.

3. The use of antimicrobials should be based on evidence from continuous monitoring of disease, including laboratory diagnosis of samples from sick and dead animals. Prophylactic use of antimicrobials should not be practised on a routine basis.

4. Early diagnosis and treatment should be practised to prevent chronic pneumonia.

5. Calves showing severe respiratory distress after multiple treatments should be humanely killed on the farm.

## 3.6. Beef cattle: risk assessment conclusions

### 3.6.1. Introduction

The most important risks to the welfare of beef cattle farming systems are presented in Table 6. These have been extracted from the full risk assessment exercise. The methodology and complete risk assessment results are presented in Appendix 2.

The hazards included in Table 6 were chosen on the basis of the magnitude of the adverse consequence (intensity x duration) and the probability of occurrence in the population (probability of adverse consequence when exposed to the hazard x probability of exposure within the population).

The inclusion criteria for this list of main hazards were those hazards that had a very high magnitude with a probability equal or above 2 % and those with a high magnitude and a probability equal or higher than 10 %.

**Table 6:** Beef cattle: risk assessment main outcomes.

| TARGET POPULATION: Beef cattle | | | | | Risk Assessment | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Hazard identification | | | Risk characterisation | | | | |
| Section | Sub-section | Welfare outcome | Hazard description | Hazard specification | Magnitude | Probability of the event | | | Uncertainty |
| | | | | | | ML | CI5% | CI95% | |
| **Housing** | | | | | | | | | |
| | | Heat stress | THI > 78 | Without insulation | High | 16% | 9% | 21% | High |
| | | | | Without adequate ventilation | High | 19% | 12% | 23% | High |
| | | Respiratory disease | Air space < 20 $m^3$/animal | With adequate ventilation | High | 11% | 7% | 16% | High |
| | | | | Without adequate ventilation | High | 11% | 6% | 15% | High |
| | | | Air quality | Ammonia > 20 ppm | High | 10% | 8% | 15% | High |
| | **Pen design** | Lameness | Concrete floors | | High | 12% | 9% | 14% | High |
| | | Behavioural restriction | Tethering | | Very High | 5% | 3% | 8% | High |
| | **Space allowance** | Behavioural restriction | Insufficient space allowance | Floor space < 3 $m^2$/animal | High | 40% | 28% | 52% | High |
| | | Aggression and injury | Insufficient space allowance | Floor space < 3 $m^2$/animal | High | 28% | 19% | 37% | High |
| | | Respiratory disease | Insufficient space allowance | Floor space < 3$m^2$/animal | High | 28% | 19% | 37% | High |
| **Management** | | | | | | | | | |
| | **Nutrition and feeding** | Subacute ruminal acidosis | High starch/fibre ratio in diet | Intensive concentrates | High | 22% | 15% | 31% | Medium |
| | | Laminitis | Intensive concentrates | | Very High | 4% | 3% | 6% | Medium |
| | | | Forage + concentrates | | Very High | 3% | 2% | 4% | Medium |
| | | Para- and hyperkeratosis | Intensive concentrates | | High | 21% | 14% | 31% | Medium |
| | | | Forage + concentrates | | High | 12% | 7% | 15% | Medium |
| | | Undernutrition | Cattle at pasture | | Very High | 12% | 7% | 20% | High |
| | **Feed-related behavioural disorders** | Tongue rolling | Intensive concentrates | | High | 15% | 10% | 21% | High |
| | | Urine drinking | Intensive concentrates | | High | 11% | 7% | 16% | High |
| | **Grouping of animals** | Respiratory disease | Co-mingling in feedlot | Without pre-conditioning | High | 11% | 7% | 16% | High |
| **Disease management** | | | | | | | | | |
| | **Respiratory disease** | Respiratory disease | Delay in BRD diagnosis | No metaphylaxis | High | 26% | 20% | 30% | High |
| | | | Prior transport | | High | 22% | 21% | 23% | Medium |
| | **Other diseases** | Disease | No planned herd health programme | | Very High | 31% | 25% | 35% | High |
| | | Parasitism and undernutrition | No pasture management | | Very High | 2% | 2% | 3% | High |

# 4. CALVES

## 4.1. Introduction

As outlined in the general introduction, this Chapter presents an update of the previous Opinion "The risks of poor welfare in intensive calf farming systems - An update of the Scientific Veterinary Committee Report on the Welfare of Calves" adopted by the EFSA Panel on Animal Health and Welfare (AHAW) in May 2006 (EFSA, 2006).

Council Directive 91/629/EEC[6], laying down minimum standards for the protection of calves (amended by Council Directive 2008/119/EC[7]), required the European Commission to submit a report to the Council, based on a Scientific Opinion on intensive calf farming systems which comply with the requirements of the well-being of calves from the pathological, zootechnical, physiological and behavioural points of view.

The Scientific Veterinary Committee (Animal Welfare Section) adopted a report on the welfare of calves (SVC, 1995) which served as a background to the Commission's request and the preparation of the 2006 EFSA Scientific Opinion. In particular, the Commission required EFSA to consider the need to update the findings of the Scientific Veterinary Committee's Opinion in light of recent data available on this issue.

The EFSA 2006 Opinion was the first to apply a risk assessment approach to facilitate the ranking of risks of poor welfare for calves, and to produce relevant conclusions and recommendations forming the Scientific Opinion from the AHAW Panel.

For the purpose of the present Opinion, a calf in an "intensive farming system" is one that has been born to a dairy cow, separated from its mother shortly after birth, and reared artificially for the production of white or pink veal, or until such time as it enters a beef production system. The welfare of this latter group of calves after entry to beef production systems has been reviewed in Chapter 3 of this Opinion.

The structure of this Opinion follows the structure of the EFSA 2006 Opinion and, to give the reader a complete overview of the welfare of calves, they should be used together.

In both Opinions the objectives are:

- to review and report recent scientific literature on the welfare including the health of intensively reared calves,
- to report on recent findings as an update to the Scientific Veterinary Committee's previous report,
- to make a qualitative risk assessment concerning the welfare of intensively kept calves.

In cases where the information provided in the 2006 Opinion (EFSA, 2006) remains valid today, the present Opinion simply states "*No critical new information to be added to section XX of the previous Opinion*". There has been considerable new research into two of the most important welfare problems for intensively-reared calves, namely: a) physiological, pathological and behavioural problems associated with the feeding of calves reared for white veal, including iron-deficiency anaemia; and b) infectious diseases, including the use of antibiotics.

[6] Council Directive 91/629/EEC, of 19 November 1991, laying down minimum standards for the protection of calves. OJ L 340, 11.12.1991, p. 28–32.

7 Council Directive 2008/119/EC of 18 December 2008, laying down minimum standards for the protection of calves. OJ L 10, 15.01.2009, p. 7-13.

To comply with the scope of the mandate, food safety aspects of calf farming systems (although addressed in EFSA, 2006), methods of transport and slaughter have not been considered in this Opinion.

## 4.2. Calf production systems

Some new information is added to the text of Section 8. of the EFSA Opinion (2006).

### 4.2.1. Artificially-reared, early-weaned calves from the dairy herd

Calves born to dairy cows are separated from their mothers shortly after birth. They must receive colostrum and are then reared with whole milk or milk replacer, progressively supplemented by a cereal-based concentrate starter ration and forage (hay, silage or straw) as a source of fibre. The age at which calves are weaned off milk or milk replacer differs according to the region or country. Most calves are weaned between the ages of 4-8 weeks. Female, dairy-type calves (Holstein/Friesian) are reared to become replacement heifers for the dairy herd, but their welfare is not considered in this Opinion. Male and female half-bred calves from dairy cows inseminated with semen from beef-type bulls (e.g. Aberdeen Angus, Charolais) will be reared for beef in intensive or semi-intensive systems, as described in Chapter 3. Some male dairy-type calves having suitable conformation can be reared for beef in intensive systems. Others, of a more extreme dairy type may be destined for veal production or killed as unwanted shortly after birth and before registration (see Table 2).

### 4.2.2. White veal

Some new information is added to the text of Section 8.2.1.1. of the EFSA Opinion (2006).

Calves reared for the production of white veal are fattened for approximately 20-26 weeks on a predominantly liquid, milk-replacer diet. According to the law (Council Directive 2008/119/CE), calves reared for veal should also receive sufficient iron to ensure an average blood haemoglobin of at least 4.5 mmol/l, and calves over 2 weeks old should be provided daily with some fibrous feed which should increase from 50 to a minimum of 250 g/d from the beginning to the end of the fattening period.

### 4.2.3. Pink veal

Some new information is added to the text of Section 8.2.1.1. of the EFSA Opinion (2006).

In The Netherlands, pink veal meat is generally produced from calves of dairy breeds. Pink veal calves are weaned at 8-9 weeks of age. After weaning, they receive an *ad libitum* diet of roughage (frequently maize silage) and by-products. Pink veal calves are not restricted with regard to dietary iron supply and, consequently, develop normal haemoglobin levels and the associated “red” (pink) meat colour. In France, the calves are most often from suckler beef breeds, and they are reared with their dam and may be weaned before the end of rearing. The age at slaughter can vary from calves of 5-8 months to young-bred animals of 8-11 months with the slaughter age of individuals depending on the production rate. These products are labelled to help consumers distinguish them from white veal meat.

## 4.3. Comparison of systems and factors

### 4.3.1. Feeding and housing systems, weaning strategies and quality of solid and liquid feed

#### 4.3.1.1. Feeding systems

Some new information is added to the text of Section 9.1.1. of the EFSA Opinion (2006).

The majority of white veal calves fattened in Europe are kept in a group housing system with groups of 5 - 7 calves per pen. These animals receive a milk replacer diet, supplemented with (some) solid feed. Milk replacer is provided in a trough or, on a minority of farms, in individual buckets, usually as two meals per day.

High feeding levels of milk replacer in combination with a limited number of meals per day have been associated with several physiological disturbances in veal calves, including hyperglycemia, glucosuria (i.e. excretion of glucose in urine) and insulin resistance (Hostettler-Allen et al., 1994; Hugi et al., 1997). A recent study by Vicari et al. (2008) shows that these physiological disturbances were largely prevented by decreasing the feeding level and increasing the feeding frequency to four times daily.

The use of large group housing systems combined with automatic milk replacer feeders in veal production would allow for a substantial increase in the frequency of milk replacer meals even beyond four times daily, thereby possibly alleviating or preventing disturbances in glucose metabolism associated with hyperglycemia, glucosuria and insulin resistance. However, although automatic milk replacer feeders are increasingly used, in particular in the rearing of replacement heifer calves, a number of main problems remain including cross-sucking (i.e. non-nutritive sucking of parts of another calf's body), and a high incidence of (respiratory) disease (Jensen, 2003; Svensson and Liberg, 2006; Brscic et al., 2009; Roth et al., 2009a; Marcé et al., 2010; De Passillé et al., 2011).

#### 4.3.1.2. Weaning strategies

Some new information is added to the text of Section 9.1.1. of the EFSA Opinion (2006).

Intensively kept veal calves generally originate from dairy herds where new-born calves are separated from their mothers shortly after birth, and subsequently raised on a milk or milk replacer diet. From a nutritional point of view, white veal calves are never truly weaned since they receive increasing amounts of milk replacer during the entire fattening period. Pink veal calves, in contrast, usually receive milk replacer next to solid feed until 6-8 weeks after arrival at the fattening unit, at which time provision of liquid feed is stopped and fattening continues on a solid feed diet (roughage, concentrates and by-products) only. Thus, weaning strategies applied in the dairy industry on replacement heifer calves may also be relevant for pink veal. In recent studies, the main potential determinants of weaning strategies that were examined in dairy calves include: (i) weaning age, (ii) duration of weaning, and (iii) milk replacer and/or solid feed intake in relation to body weight. De Passillé et al. (2011) showed that delaying the age at which calves are weaned off milk from 47 to 89 days reduced the drop in energy intake and the behavioural signs of hunger that results from weaning. Different times and durations of weaning were examined by Sweeney et al. (2010), and their study showed that weaning occurred at 6 weeks of age, but the weaning process was started either 0 (abrupt weaning), 4, 10 or 22 days prior to that. During the 9 days following weaning, calves weaned over 22 and 10 days ate more starter and had better weight gains than abruptly weaned calves and those weaned over 4 days. Abruptly weaned calves even lost weight during this period. During the period before weaning, however, abruptly weaned calves had higher digestible energy intakes and weight gains. The best overall weight gains during rearing were exhibited by calves weaned over a 10-day period prior to full weaning at 6 weeks of age.

Thus, appropriate weaning is all about optimising pre-weaning milk (i.e. digestible energy) intake and post-weaning intake of solid feed. Weaning too early may hamper pre-weaning growth, whereas weaning too late may compromise solid feed intake and, thereby, proper rumen development (Khan et al., 2011a; Kosiorowska et al., 2011). It has been shown that making the amount of milk provided during the pre-weaning period dependent on either body weight (Khan et al., 2007a) or the consumption of concentrate (Maas and Robinson, 2007; Roth et al., 2009b) may be important tools for the development of gradual or stepwise weaning strategies.

#### 4.3.1.3. Quality of solid and liquid feed

Some new information is added to the text of Section 9.1.3. of the EFSA Opinion (2006).

<u>Solid feed: concentrates and roughage</u>

Provision of solid feed to white veal calves is becoming more important because, with increasing prices of milk replacer ingredients, there is an increasing economic incentive to substitute milk replacer for solid feeds (concentrates and/or roughage). This means that, as with pink veal calves, proper rumen development becomes an essential biological condition in white veal as well, and is necessary for calves to digest and utilise nutrients properly from their diet.

However, research indicates that providing solid feed to milk-fed veal calves may also be associated with a number of negative side-effects, including high prevalences of abomasal lesions (see previous EFSA Opinion, 2006; Bähler et al., 2010; Brscic et al., 2011), and the formation on the ruminal wall of so-called "plaque" (i.e. patches of focal mucosa inflammation with coalescing and adhering papillae covered by feed particles, hair and cell debris; Suárez et al., 2006; Brscic et al., 2011).

High prevalences of abomasal – in particular pyloric – lesions in white veal calves fed large volumes of milk replacer are believed to result from overfilling of the abomasum, causing local ischemia followed by focal necrosis as a consequence of strong contractions of the pyloric wall. Provision of roughage, in turn, would then exacerbate an existing problem because roughage particles exert a mechanically abrasive effect on an already sensitive abomasal mucosa, and delay the healing of lesions already present. This hypothesis was supported by findings that prevalences of abomasal ulcers in weaned bull calves and veal calves fed milk replacer only were 0 % and between 20-25 %, respectively. Moreover, this hypothesis would predict that prevalences of abomasal lesions in pink veal calves (i.e. weaned calves fattened on solid feeds only) would be relatively low. Recent findings, however, have provided seemingly inconsistent results. In one survey examining a total of 247 abomasa (distributed across nine different pink veal farms), less than 20 % contained one or more pyloric ulcers (Van Reenen et al., 2007). In a more large-scale survey (as part of a comprehensive veal calf welfare monitoring study, which also involved observations in white veal calves; see Brscic et al., 2011), looking at approximately 2,000 abomasa from a total of 50 pink veal farms in The Netherlands (on average 40 abomasa per farm), the overall prevalence of pyloric lesions was 56 % (against 74 % in white veal calves; see Brscic et al., 2011). Although in this latter survey any kind of pyloric lesion was recorded (from erosion to perforating ulcer), the relatively high prevalence of pyloric lesions among a large sample of pink veal calves suggested that the aetiology of abomasal lesions in veal calves also involved other factors than those related to the interaction between milk replacer and solid feed. Factors involved in the pathogenesis of abomasal ulcers in pink veal calves may be similar to those assumed to be implicated in the development of abomasal ulcers of beef cattle (Marshall, 2007, 2009; Van Immerseel et al., 2010).

The composition of solid feed provided to veal calves, in terms of the concentrate to roughage ratio, was found to be critical in the occurrence of ruminal "plaque". Provision of different types of 100 % concentrate (to a maximum of 750 g of dry matter per day) in addition to a commercial milk replacer always resulted in high prevalences of ruminal "plaque" (between 73 and 100 %; Suárez et al., 2006). Adding roughage to the concentrates (30 % of total dry matter) virtually eliminated this problem (Suárez et al., 2007). This agrees with the absence of "ruminal plaque" in dairy calves fed starter concentrates in combination with chopped grass (Khan et al., 2007b, 2008), and with recent field observations in white veal calves showing that the probability for "ruminal plaque" to occur was significantly increased in animals fed mainly cereal grain relative to animals provided with maize silage. However, adding forage to concentrates may have wider implications than ruminal health alone, since Khan et al. (2011b) found that, in comparison with *ad libitum* starter only, the provision of chopped hay next to starter promoted solid feed dry matter intake and rumen development without affecting growth in rearing calves monitored between 3 and 70 days of age.

A balanced composition of solid feed provided to (veal and dairy) calves is also important for proper rumen development and a healthy ruminal environment (e.g. in terms of acidity; Suárez et al., 2007; Khan et al., 2011b). In comparison with late rumen development, early rumen development induced by early provision of solid feed consisting of maize silage, barley straw and concentrate (25:25:50 on a dry matter basis) in milk-fed veal calves was shown to result in an improved feed efficiency and growth performance during the second half of the fattening period, and a reduction in the prevalence of large abomasal scars at slaughter (Berends et al., in press). This latter finding would suggest that (early) rumen development may also interact with abomasal health, but this needs to be confirmed.

Provision of solid feed next to milk replacer may be beneficial for the behaviour of veal calves in that it reduces the expression of abnormal oral behaviours and stimulates rumination (see EFSA, 2006). However, a recent study by Webb et al. (2012) suggests that provision of roughage may not exert these beneficial effects in a simple dose response fashion (i.e. where the higher the amount of solid feed, the lower the level of abnormal oral behaviours). In this latter experiment, an intermediate amount of roughage was associated with more abnormal behaviour than a relatively low amount. This was explained by the assumption that calves provided with intermediate amounts of solid feed experienced a decrease early in the fattening period in the time spent chewing and ruminating (due to an increase in chewing and ruminating efficiency over time), which led to greater frustration and higher levels of abnormal oral behaviours in comparison with the situation in calves fed relatively low amounts of solid feed, which maintained a constant, albeit relatively low, chewing frequency throughout the entire fattening period (Webb et al., 2012). Thus, it might be important to ensure a high level of chewing throughout the fattening period, especially at the beginning of the fattening period, that does not decline rapidly early on, and this may require increasing rather than constant amounts of roughage throughout this period.

Composition and quality of liquid feed

Provision of colostrum to new-born dairy calves is essential for their health and survival (see EFSA, 2006). The majority of calves fattened in intensive veal production systems in Europe are surplus bull calves from the dairy industry. The provision of colostrum to this category of calves may not be adequate on all farms, especially when calves leave the dairy farm at a very young age. Berge et al. (2009a) looked into possibilities for improving the health status of calves with the use of supplemental colostrum. On a commercial calf ranch, supplemental colostrum was provided to pre-weaned calves in the form of 70 g of colostrum powder in the milk replacer twice daily for 14 days. Supplemental colostrum during the first 2 weeks of life reduced diarrhoea and, thereby, the amounts of antimicrobial treatments needed. Supplementing calves with a colostrum product might be a valuable tool to address problems of colostrum-deprived calves, pathogen load and environmental stress in (veal) calves, and to minimise antibiotic use.

Skimmed milk protein in veal calf diets is increasingly replaced by non-milk proteins or whey. This is associated with reduced or absent milk clotting in the abomasum, and a more rapid transport of fat and proteins from the abomasum to the absorptive sites in the small intestine. It can be expected that glucose, fatty acids and amino acids under these conditions are absorbed and appear in blood more rapidly and/or in greater amounts than if derived from casein. This may result in metabolic stress, in particular when large volumes of milk replacer are provided in two meals per day (Vicari et al., 2008). Composition of milk replacers for veal calves is critical in this respect, in particular with regard to the protein source.

In this context, the findings of Frizzo et al. (2010) are relevant. These authors demonstrated that the oral administration of a microbial inoculum to young calves fed milk replacer and spray-dried whey powder promoted the consumption of starter (dry matter intake), and thereby growth, and reduced the incidence of diarrhoea of nutritional origin.

Fast feeding of high volumes of milk replacer, as may occur in feeding systems for intensively kept white veal calves, may render calves susceptible to failure of the oesophageal (reticular) groove reflex, which may lead to the accumulation of large amounts of milk replacer in the rumen ("ruminal drinking"). This, in turn, may result in several clinical and pathological signs, including ruminal acidosis (because of bacterial fermentation of milk and the production of volatile fatty acids, especially lactic acid), bloat, white and clay-like faeces, inappetance, growth retardation, hyperkeratosis in the rumen, and villus atrophy in the small intestine (Breukink et al., 1988; Van Weeren-Keverling Buisman et al., 1991; Herrli-Gygi et al., 2008). Although several factors may influence the efficiency of the oesophageal groove reflex (e.g. diseases such as pneumonia or diarrhoea, stress, age and breed of the animals), the quality and temperature of the liquid feed, and the method of provision of milk replacer (e.g. teat versus bucket) are generally considered especially relevant for (veal) calves (see Herrli-Gygi et al., 2008). Providing warm milk through a teat usually gives the highest oesophageal groove function in pre-weaned ruminants (see Wise et al., 1984).

#### 4.3.1.4. Dietary iron and anaemia

Some new information is added to the text of Section 9.1.4. of the EFSA Opinion (2006).

If dietary iron supply is insufficiently controlled, white veal calves, which are deliberately restricted with regard to the dietary iron content, may run the risk of suffering from iron deficiency anaemia. Clinically, this type of anaemia is reflected in reduced blood haemoglobin content. In humans, iron-deficiency anaemia is accompanied by clinical signs and symptoms such as fatigue, impaired thermoregulation and thyroid function, a compromised ability to cope with physical stress or exercise and a general feeling of "malaise" (Patterson et al., 2000, 2001; Ando et al., 2006; Zimmermann and Hurrell, 2007; Clark, 2008; Lucca et al., 2008; Peirano et al., 2009). These clinical signs are associated with iron-deficiency-induced functional changes of important biological systems in the body, including the cardiovascular, metabolic, neuroendocrine and immune systems. Such functional changes are related to the fact that iron is not only involved in the transport of oxygen but also represents an important (co)factor in a wide range of essential enzymatic processes (see, for example, Dallman, 1986; Rosenzweig and Volpe, 1999; Beard, 1990, 2001; Maggini et al., 2007; Wintergers et al., 2007).

Results of research in (veal) calves are in accordance with those in other species, including humans, and have demonstrated that iron-deficiency anaemia in calves may be associated with a compromised ability to cope with physical stress, lack of appetite, an increased probability of diarrhoea and respiratory infections, depression of growth, a reduction of the total number of white blood cells and the number of lymphocytes, altered functions of glucose metabolism and the hypothalamo-pituitary-adrenal axis, enhanced levels of catecholamines in urine, and an increased heart rate during drinking (Bremner et al., 1976; Reece, 1984; Postema, 1985; Reece and Hotchkiss, 1987; Gygax et al., 1993; Lindt and Blum, 1993, 1994a, b; Ceppi and Blum, 1994; Ceppi et al., 1994; Blum and Hammon, 1999; Van Reenen et al., 1999; Enjalbert, 2009).

It is relevant to mention that in humans iron-deficiency-induced functional biological changes, as well as clinical signs of iron-deficiency anaemia may occur prior to an actual decrease of blood haemoglobin levels (Oski et al., 1983; Beard, 1999; Brownlie et al., 2002; Brutsaert et al., 2003; Trost et al., 2006; Lynch et al., 2007). Correspondingly, field observations in white veal calves have revealed that oral supplementation with iron may improve milk intake and digestion in animals exhibiting normal haemoglobin levels (Postema, 1985). These findings are relevant in view of the fact that in current white veal production, blood haemoglobin levels of calves are used as the key diagnostic to monitor the iron state of the animals. Most importantly, feeding management, including the provision of (additional) dietary iron, is primarily based on the results of this type of monitoring. Possibly, therefore, the systematic recording of other parameters, in addition to blood haemoglobin levels, for example, other clinical and/or clinical chemical indicators of anaemia and iron state, might be necessary to safeguard the welfare of veal calves restricted in their dietary iron supply.

Since iron does not only benefit the "host", but also plays an important role in the stimulation of the growth of pathogens, the provision of iron to individuals who are infected with pathogens may be associated with serious side-effects (Gera and Sachdev, 2002; Schaible and Kaufmann, 2004; Bullen et al., 2006; Hershko, 2007; Markel et al., 2007; Ratledge, 2007). Such side-effects mainly occur in so-called iron-replete individuals (i.e. individuals with sufficient iron in the body; Sazawal et al., 2006; Lynch et al., 2007; Prentice, 2008; Stoltzfus, 2008). This recognition has influenced, for example, the approach to the problem of solving iron deficiency anaemia in children, taken by the World Health Organization (WHO), since there is now a wide scientific consensus that generic treatment with supplemental iron of children in areas with high infection rates of malaria or other diseases should be avoided, and that provision of iron should be restricted to iron-deficient rather than iron-replete subjects (Oppenheimer, 2001; Ianotti et al., 2006; Stoltzfus et al., 2007; WHO, 2007; Stoltzfus, 2008).

In the context of the production of white veal, this means that treatment with supplemental iron should take place as much as possible at the level of the individual animal rather than the herd, and that the infection state of the animals should be carefully taken into consideration in this respect.

*Conclusions*

1. Several physiological disturbances in veal calves, including hyperglycemia, glucosuria (excretion of glucose in urine), insulin resistance, and abomasal overload caused by high feeding levels of milk replacer and limited number of meals per day can be prevented by decreasing the feeding level and increasing the feeding frequency.

2. The provision of solid feed for white veal calves containing adequate amounts of functional fibre is a prerequisite for the development of a healthy and functional rumen, the prevention of abnormal oral behaviours, and the stimulation of normal rumination activity.

3. High feeding levels of milk replacer in combination with a limited number of meals per day have been associated with physiological disturbances in veal calves, including hyperglycaemia, glucosuria, insulin resistance, and “ruminal drinking”. Decreasing the feeding level and increasing the feeding frequency may help to alleviate these problems.

4. Clinical signs and symptoms of iron-deficiency anaemia may occur prior to an actual decrease of blood haemoglobin levels.

5. In humans, the provision of iron to individuals who are infected with pathogens may be associated with serious side-effects. This may also be the case for farm animals, including veal calves.

*Recommendations*

1. The feeding frequency of milk replacer in white veal calves should be increased, preferably to more than three meals a day, in order to alleviate problems associated with a disturbed glucose metabolism and metabolic stress. The effect of feeding level and feeding frequency on metabolic and other health problems in veal calves requires further research.

2. Addition to Recommendation 2. c) of Section 9.1.4. of the EFSA Opinion (2006; see UR.1 in the Conclusions and Recommendations section): Other clinical and biochemical parameters, in addition to blood haemoglobin levels, should be included as indicators of anaemia in order to safeguard the welfare of veal calves restricted in their dietary iron supply. This topic requires further research.

3. In the context of the production of white veal, treatment with supplemental iron should take place as much as possible at the level of the individual animal rather than the herd.

4. The white veal industry should be required to provide figures for the concentration and concentration ranges of blood haemoglobin in the EU population of white veal calves, throughout the fattening period, and on the incidence of diseases.

### 4.3.2. General housing

Some new information is added to the text of Section 9.2. of the EFSA Opinion (2006).

Recent studies have shown that of all the possible housing conditions relevant for the welfare of calves, group size is especially important with regard to the respiratory health of the animals. A large-scale survey on 174 white veal farms located in the three main veal producing countries in Europe (France, Italy and The Netherlands) has revealed that the risk for difficult respiration (indicative of clinical pneumonia) at the beginning of the fattening period (3 weeks after arrival of the calves at the fattening unit) increased with increasing group size (Brscic et al., 2012). The odds ratio (OR) for difficult respiration was significantly increased in calves housed in the largest groups (> 15 animals), in comparison with calves housed in the smallest groups (≤ 6 calves; OR 3.8, $P < 0.02$). The largest groups mainly referred to farms providing milk replacer with an automatic milk dispenser. This finding closely agrees with the results of Svensson and Liberg (2006) in replacement heifer calves, reported in the previous Opinion (EFSA, 2006), that the risk of respiratory disease was increased in calves housed in large pens with an automatic milk-feeding system. Although not significantly different from ORs obtained in small groups (≤ 6 calves), numerically higher ORs for difficult respiration in white veal calves at 3 weeks after arrival at the fattening unit were obtained in intermediate groups (7-9, or 10-15 calves per pen, respectively, ORs 1.4 and 2.6; Brscic et al., 2012). This agrees with higher incidences of respiratory disease that were observed in relatively large groups of heifer calves (12-18 animals per pen) in comparison with relatively small groups (6-9 animals per pen) housed in pens with automatic milk-feeders (Svensson and Liberg, 2006).

***Conclusions***

1. Especially at the beginning of the fattening period, veal calves housed in large groups (> 15 calves) may be more at risk for respiratory disease than animals kept either individually or in small groups (< 6 calves).

### 4.3.3. Space and pen design

#### 4.3.3.1. Recent findings regarding importance of space

Some new information is added to the text of Section 9.3.1. of the EFSA Opinion (2006).

The space of the lying area may influence the resting and social behaviour of calves. A reduction of the lying space allowance from 1.25 $m^2$ to 0.75 $m^2$ per animal for calves with a live weight up to 100 kg and a reduction from 1.50 $m^2$ to 1.00 $m^2$ per animal for calves with a live weight up to 150 kg, decreased the occurrence of synchronous resting, lowered the calves possibility to lie in a relaxed recumbent posture with legs stretched out, and increased the occurrence of calves resting in close proximity to others (Faerevik et al., 2008). This study supports the current legislation on the minimum standards for the protection of calves (Council Directive 2008/119/CE).

Restricting feeding space for the intake of solid feed in young growing heifers (i.e. by increasing the number of animals per feed bin or concentrate feeding place beyond one) increases social competition, and increases day-to-day variation in feeding behaviour and performance (Gonzalez et al., 2008; DeVries and von Keyserlingk, 2009). Increasing social pressure at concentrate feeders beyond the threshold of four animals per feeding place negatively affects growth.

#### 4.3.3.2. Recent findings regarding importance of pen design

Some new information is added to the text of Section 9.3.2. of the EFSA Opinion (2006).

Ude et al. (2011) have examined an innovative modification of the design of a pen for group-housed calves fed milk replacer with an automatic teat feeder. More specifically, these authors introduced a so-called “environmentally-enriched post-feeding area” into the group-pen, on the assumption that this would reduce cross-sucking. They found that adding a post-feeding area to an automatic milk feeding system significantly reduced cross-sucking in group-housed calves, and had no effect on other behaviours related to milk intake or feeding on hay and concentrates.

***Conclusions***

1. A reduction of the lying space allowance from 1.25 $m^2$ to 0.75 $m^2$ per animal for calves with a live weight up to 100 kg and a reduction from 1.50 $m^2$ to 1.00 $m^2$ per animal for calves with a live weight up to 150 kg, decreased the occurrence of synchronous resting and reduced the possibility to lie in a relaxed recumbent posture.

2. Addition of an environmentally-enriched post-feeding area to an automatic milk feeding system may reduce cross-sucking in group-housed calves reared for white veal.

***Recommendations***

1. More research should be focused on pen design to improve calf comfort and achieve environmental enrichment.

### 4.3.4. Flooring and bedding material

4.3.4.1. Recent findings regarding importance of floor and bedding materials

Some new information is added to the text of Section 9.4.1. of the EFSA Opinion (2006).

So far, in contrast to dairy cattle and fattening bulls, only a few mainly small-scale studies have systematically examined the effect of floor type on the welfare of calves. Yanar et al. (2010) made a comparison between wooden slats, rubber mats and concrete, and used individually-housed calves (25 animals, 14 male and 11 female) randomly distributed across the three floor-types. In this particular study, all pens were bedded daily with 2 kg of lying wheat straw. At 4 months of age, the total average weight gain of calves housed on wooden slats was significantly higher than the total average weight gain of calves housed on rubber mats. However, it was suggested that this result might be attributed to dirty and wet bedding material (i.e. long straw) which may have resulted in discomfort for the calves on the rubber mats (Yanar et al., 2010). An experiment with 28 individually-housed dairy calves examined from birth to weaning (at approximately 8.5 weeks) found no differences in health (respiratory health, faecal health) or growth between three different bedding materials (i.e. straw, wood shavings or sand; Gay et al., 2010a). In this study, fly larvae counts were highest in hutches bedded with straw (Gay et al., 2010b), suggesting that straw, wood shavings and sand are all acceptable bedding materials, but that fly larvae counts have to be controlled when straw is used.

In a large-scale survey on a total of 174 white veal farms (Brscic et al., 2011), calves were housed either on wooden slats (138 farms), rubber or straw (11 farms), and concrete (25 farms). On each farm, the prevalence of swelling of the bursa in the knee was obtained based on clinical observations in a random sample of, on average, approximately 250 calves of the same batch. Clinical observations were performed at three time-points: at 3 and 13 weeks after arrival of the batch of calves at the fattening unit, and 2 weeks before slaughter. The prevalence of swelling of the bursa increased over time, except in calves housed on rubber or straw. Two weeks before slaughter, the average prevalence of swelling of the bursa in the knee was significantly higher in calves housed on concrete (about 17 %) than that in calves housed either on wooden slats (about 7 %) or on rubber or straw (< 1 %). The difference in average prevalence of swelling of the bursa in the knee was also significantly higher in calves housed on wooden slats than calves housed on rubber or straw.

A study involving 135 Norwegian dairy herds, aimed at identifying risk factors for calf diarrhoea found an increased risk for diarrhoea on farms with concrete slatted floors in group pens relative to farms with other floor types (without specifying what the floor types were other than concrete slatted floors; Gulliksen et al., 2009a).

***Conclusions***

1. At present, white and pink veal calves are almost exclusively kept on wooden slatted floors and concrete slatted floors, respectively. The available data, however, suggest that other floor types may be more comfortable and may possibly provide health benefits. There is some evidence that floor type may have an effect on the health of artificially reared calves, in particular with regard to the risk of diarrhoea, which was higher on farms with concrete slatted floors relative to farms with other floors.

2. The prevalence of bursal swelling in the knee was significantly higher in white veal calves housed on concrete (about 17 %) than that in calves housed either on wooden slats (about 7 %) or on rubber or

straw (< 1 %). The difference in average prevalence of swelling of the bursa in the knee was also significantly higher in calves housed on wooden slats than calves housed on rubber or straw.

3. Provision of small amounts of straw or rubber mats for veal calves on wooden slats can result in discomfort due to dirty and wet floors, unless these floors are well managed.

***Recommendations***

1. Welfare-friendly floor types and their alternatives should be researched for intensively kept veal calves, particularly for the relationship between floor type and (veal) calf health, such as diarrhoea.

### 4.3.5. Degree of social contact

No critical new information to be added to Section 9.5. of the EFSA Opinion (2006).

#### 4.3.5.1. Recent findings regarding contacts with the dam

Some new information is added to the text of Section 9.5.1. of the EFSA Opinion (2006).

Roth et al. (2009c) compared calves reared with an automatic milk dispenser with animals that were reared with unrestricted or restricted contact with their own mother. During the milk feeding period, weight gain was greater in mother-fed calves, which could be explained by a higher milk intake. After weaning, the weight gain of all treatment groups was diminished, but this effect was stronger in mother-fed calves. Rearing with either restricted or unrestricted contact with the dam prevented the development of cross-sucking. However, the health of mother-fed calves, in particular with regard to diarrhoea, was poorer than that in artificially-reared animals. It was concluded that both permanent and restricted contact with the mother during rearing had great behavioural advantages, but that there was an unfavourable effect of rearing with the dam due to higher incidence of diarrhoea, probably because of the large amount of milk ingested by the calves (Roth et al., 2009c). A similar comparison between calves given milk from an automatic feeder and calves allowed to suckle from the dam was made by Fröberg and Lidfors (2009). In contrast to calves kept in groups with an automatic milk feeder, suckled animals displayed no cross-sucking and tongue rolling. Calves suckled by the mother ate less solid feed than artificially reared animals (Fröberg and Lidfors, 2009), which may be related to differences in milk intake. Also, in a more recent study examining the development of sucking and other behaviours in housed dairy calves nursed by their dam no cross-sucking events between calves were observed (Lidfors et al., 2010).

#### 4.3.5.2. Recent findings regarding contacts with the other calves

Some new information is added to the text of Section 9.5.2. of the EFSA Opinion (2006).

Calves are capable of developing long-lasting social relationships with their peers (Raussi et al., 2010). For example, in comparison with less familiar animals, they spent more time in proximity to calves they had been housed together with from the age of 2 weeks, and these latter calves were more often nearest neighbours than less familiar calves. Based on these findings, it was suggested that the social behaviour of calves would be enhanced if animals were not transferred from one group to another individually, but instead together with a peer so that some preferential relationships would be maintained (Raussi et al., 2010). Moreover, it was recommended that animals should be kept with peers known from an early age. In an intensive veal production system, however, it would be very difficult if not impossible to implement this recommendation.

When it comes to social behaviour, group size appears to interact with familiarity between calves. Faerevik et al. (2007) looked at social behaviour of calves kept in newly created groups of 4, 8 or 16 animals, in which half of the calves in each group were unfamiliar with each other. Calves in larger groups were generally more active, displaced other calves less frequently from the feed barrier, and performed more positive social interactions with familiar calves during the first 1-3 days after regrouping.

In addition to the level of familiarity between animals, homogeneity within groups of calves in terms of age may affect the welfare of calves. Housing calves with a difference in age of more than 8 weeks together in the same group increased the risk of respiratory disease compared with having pen mates of a more similar age (Gulliksen et al., 2009b). Similarly, calves in heterogenous groups (including six young animals, aged between 30 and 42 days, and six old animals, aged between 70 and 94 days at entry into the group pens) showed increased competition during feeding and reduced average growth rates relative to calves in homogeneous groups (aged between 30 and 54 days; Faerevik et al., 2010).

#### 4.3.5.3. Comparison between individual housing vs. group housing

Some new information is added to the text of Section 9.5.3. of the EFSA Opinion (2006).

Within the EU, group housing is compulsory for all calves older than 8 weeks of age, including intensively kept animals (Council Directive 2008/119/CE). Clearly, compared with permanent individual housing, group housing is beneficial for the welfare of calves from the perspective of possibilities for social behaviour, and the facilitation of feeding behaviour and feed intake (in particular solid feed; Hepola et al., 2006; Vieira et al., 2010).

At the same time, however, group housing of calves, especially young animals, is generally identified as a risk factor for enteric and respiratory infectious diseases (Gulliksen et al., 2009a; Marcé et al., 2010; Lorenz et al., 2011; Brscic et al., 2012). Thus, it is usually advised to house calves in individual pens for several weeks after birth before moving them to collective pens (e.g. Marcé et al., 2010). Individual housing prior to group-housing is also widely practised in veal production systems in Europe. This is also intended to reduce cross-sucking at the beginning of the fattening period.

It remains unclear at what particular age individually-housed calves should be transferred to group housing from a health point of view (see also EFSA, 2006). Research by Bach et al. (2011) may provide a novel approach to the reduction of health problems in group housed dairy calves. Calves were housed in individual hutches until weaning at the age of 58 days. Before weaning, the incidence of bovine respiratory disease was individually recorded on a daily basis. Following weaning, calves were moved to group pens of eight calves each, based on their respiratory disease history. In groups of calves with and without a previous history of respiratory disease, morbidity was higher than in groups of calves that were not previously affected by respiratory problems before grouping. More research is needed to examine the feasibility and efficacy of pre-screening individually-housed calves prior to group housing under intensive husbandry conditions.

***Conclusions***

1. Addition to Conclusion 2 of Section 9.5. of the EFSA Opinion (2006; see UC.2 in the Conclusion and Recommendations section): Group housing of calves results in better welfare for this social species, except when there is significant risk of enteric or respiratory infectious diseases.

***Recommendations***

1. Addition to Recommendation 1 of Section 9.5. of the EFSA Opinion (2006; see UR.2 in the Conclusion and Recommendations section): In order to minimise the risk of poor welfare, calves should be managed so as to minimise exposure to enteric and respiratory infection.

2. Since calves have to be kept in groups after 8 weeks of age, supervision should be required in the period after mixing to ensure that all calves learn how to feed effectively.

3. More research should be carried out to examine the optimal age and strategy for moving individually-housed calves to group housing under intensive husbandry conditions.

### 4.3.6. Temperature, ventilation and air hygiene

No critical new information to be added to Section 9.6. of the EFSA Opinion (2006).

#### 4.3.6.1. Temperature and relative humidity

No critical new information to be added to Section 9.6.1. of the EFSA Opinion (2006).

#### 4.3.6.2. Air Quality

No critical new information to be added to Section 9.6.2. of the EFSA Opinion (2006).

Ammonia ($NH_3$) and hydrogen sulphide ($H_2S$)

No critical new information to be added to Section 9.6.2.1. of the EFSA Opinion (2006).

Air and surface hygiene

Some new information is added to Section 9.6.2.2. of the EFSA Opinion (2006).

High stocking density, high concentrations of bacterial aerosols and direct contact between calves have been identified as major risk factors for the transmission of respiratory disease and, hence, when there is an outbreak of respiratory disease there should be decreased contact between very young calves within the same building (Wathes et al., 1988, Gorden and Plummer, 2010). These studies highlight the importance of reducing the risk of transmission of infection by contagion and short-range aerosol transmission when respiratory disease is present within a group of young calves.

Light

No critical new information to be added to Section 9.6.2.3. of the EFSA Opinion (2006).

Air movement

No critical new information to be added to Section 9.6.2.4. of the EFSA Opinion (2006).

#### 4.3.6.3. Ventilation

No critical new information to be added to Section 9.6.3. of the EFSA Opinion (2006).

***Conclusions***

1. Aerial pollutants in confined animal houses are detrimental to respiratory health. Primary and opportunistic microbial pathogens may cause directly infectious and allergic diseases in farm animals, and chronic exposure to some types of aerial pollutants may exacerbate multi-factorial environmental diseases, especially the respiratory disease syndrome. The environmental factors include too low temperatures, high ammonia concentrations, overstocking and poor ventilation resulting in low air quality.

2. Low ammonia concentrations reflect increased air movement, which may affect respiratory disease through increased cold stress.

***Recommendations***

1. Ventilation should be regulated to keep ammonia concentrations as low as possible without creating draughts at the calf level.

### 4.3.7. Human-animal relationships

Some new information is added to the text of Section 9.7. of the EFSA Opinion (2006).

As already mentioned in Section 3.5.6.2. of this Opinion, earlier studies have shown that human contact during the first few days following weaning appears more efficient and durable than the same procedure performed 6 weeks later. Breed may affect this early handling experience, since, in Salers calves, positive effects of additional human contact at an early age on fear of humans only occurred in calves born to docile dams (Boivin et al., 2009).

### 4.3.8. Dehorning and castration

Some new information is added to the text of section 9.8. of the EFSA Opinion (2006).

Dehorning is not an issue for young calves. In contrast, disbudding has a very significant welfare impact on female dairy calves because of the high number of animals affected. Males from dairy farms are disbudded in some countries if they are destined for beef but not if they go into veal production. Since the methods and the analgesia protocols have already been addressed, this section should be cross-referenced with the beef cattle Chapter of this Opinion.

Castration is not an issue in veal calves because this procedure is very seldom carried out. However, cross-reference with the beef cattle Chapter is advisable.

***Conclusions***

1. Calves reared for white veal are neither disbudded nor castrated. Disbudding is performed in young calves from the dairy herd destined for beef or dairy production, but the methods and pain management protocols are the same as those included in the beef cattle Chapter of this Opinion.

***Recommendations***

For recommendations dealing with disbudding in calves, the reader should refer to the mutilation section in the beef cattle Chapter of this Opinion (Section 3.5.1.).

### 4.3.9. Calf diseases and use of antibiotics

Some new information is added to the text of Section 10. of the EFSA Opinion (2006).

#### 4.3.9.1. Epidemiology

New section.

A Norwegian study (Gulliksen et al., 2009b) showed that respiratory disease increased the risk of death in all age groups in the first year of life but diarrhoea only increased the risk of death among calves younger than 1 month of age.

Being born in a single cow calving pen or in multiple cow calving pens did not affect the risk of calf disease after up to 90 days of life (Pithua et al., 2009) but the epidemiological data from the vast majority of investigations has shown considerable differences in morbidity and mortality of calves among different farms. In Sweden, the mortality of calves under 90 days of age ranged between farms from 0 to 24 % (Torsein et al., 2011). A large survey in France (Gay and Barnouin, 2009), showed that cumulative incidence of respiratory disease at the farm level was 9.8 %. Respiratory disease was more common in dairy herds than in beef ones and herd size increased the risk of BRD. Svensson and Liberg (2006) showed that diarrhoea and respiratory disease prevalence in calves to 210 days old was associated with season, a history of disease during the first 90 days of age and housing factors. Brscic et al. (2011) also found feeding and management variables to be associated with gastro-intestinal disorders in veal calves.

A recent study (Brscic et al., 2011) looked at the prevalence of gastrointestinal disorders in veal calves from The Netherlands, France and Italy. Prevalence of poor rumen development, rumen plaques and hyperkeratinisation were 60.4, 31.4, and 6.1 % of rumens, respectively, whereas abomasal lesions in the pyloric area were recorded in 74.1 % of abomasa. Feeding systems were the main risk factors for the occurrence of these gastrointestinal disorders. A low amount of solid feed (≤ 50 kg of dry matter/head per cycle) was a relevant risk for rumen underdevelopment. Rumenal plaques and hyperkeratinisation and abomasal lesions were associated with large quantities of solids (151-300 kg of dry matter/head per cycle) in calves receiving milk replacer during the entire fattening cycle. Changes adopted to improve veal calf welfare were associated with lower risk for these gastrointestinal disorders.

All available data suggest that management and housing conditions greatly influence health, welfare and survival of calves in the first 6 months of their life, and that the situation is not substantially improved by vaccination of cows against a series of infectious agents.

#### 4.3.9.2. Enteric disease

New information is added and text from Section 10.1. of the EFSA Opinion (2006) is updated.

Enteritis is the most common disease in calves less than a month old and accounts for more than half of all calf mortality on dairy farms (Radostits et al., 2007; Foster and Smith, 2009; Smith, 2009a). It is clinically recognised by the observation of faeces with a looser consistency than normal. Most calf diarrhoea problems are caused by a combination of factors, of which the most important are infections by viruses, bacteria or parasites, dietary factors, stressors and lack of passive immunity. Diseased animals usually do not have fever but are less active or even severely depressed as a result of hypoglycaemia, dehydration and acidosis (Radostits et al., 2007; Foster and Smith, 2009; Smith, 2009a). Consistency, colour and smell of the faeces are usually altered but it is not possible to differentiate between agents causing the diarrhoea by clinical findings (Radostits et al., 2007; Foster and Smith, 2009). Acidosis due to absorption of D-lactate from the gastrointestinal tract is an important cause of depression, poor welfare and death (Lorenz, 2009; Trefz et al., 2012).

No significant change in aetiology has been proposed in the last few years, but this Opinion presents a more comprehensive review of the main diarrhoea causing agents – Enterotoxigenic *Escherichia coli* (ETEC), *Cryptosporidium parvum*, rotavirus, and coronavirus. Prevalences of *C. parvum*, rotavirus, coronavirus and *E. coli* K99 in faecal samples from 147 untreated calves suffering from acute diarrhoea were 55 %, 59 %, 8 % and 5.5 %, respectively (Lanz Uhde et al., 2008), but these values can vary between farms and countries.

Other infectious agents causing neo-natal diarrhoea are *Salmonella* sp., *Clostridium perfrigens, Giardia* sp. and BVD virus.

Rotavirus is excreted through faeces of infected animals and is very resistant for several months, which is why cleaning of pens is necessary in order to break the infectious cycle (Foster and Smith, 2009). Classically, rotavirus diarrhoea is thought to be primarily a malabsorptive diarrhoea, but recent evidence indicates that there is a toxin-mediated secretory component as well (Ramig, 2004).

Bovine coronavirus is ubiquitous in cattle, being frequently isolated both from normal and diarrhoeic faeces of calves. This virus typically affects calves within the first 21 days of life, but is particularly common between days 7 and 10. Coronavirus strains have been implicated in respiratory disease in calves as well as in winter dysentery of adult cattle (Foster and Smith, 2009).

Enterotoxigenic *Escherichia coli* K99+ (ETEC) only causes diarrhoea in calves younger than 5 days (McGuirk, 2008; Foster and Smith, 2009), although *E. coli* is part of the normal intestinal flora. Since non-pathogenic *E. coli* are very common, faecal cultures are of little diagnostic value unless virulence factors such as K99 or toxins, are identified (Foster and Smith, 2009). Severity of the disease may vary but is always associated with depression and a high level of mortality (Radostits et al., 2007). Variable degrees of dehydration, acidosis, hypoglycaemia and toxaemia are common features of ETEC infection. High rectal temperature is not a reliable sign of infection as hypoglycaemia and dehydration will cause peripheral vasoconstriction and hypothermia. Parenteral or oral fluids and electrolytes are essential for the treatment of ETEC-affected calves but antimicrobials are only needed in case of systemic illness in which bacteraemia is suspected (Constable, 2004; Radostits et al., 2007; Foster and Smith, 2009; Smith, 2009b). Very dehydrated calves (> 12 %), where it has been decided that parenteral fluids will not be given, should be euthanised immediately on welfare grounds (George Stilwell, FMV-UTL personal communication, January 2012). Poor routines for transferring colostrum to the calf will increase the probability of an outbreak of *E. coli* diarrhoea and septicaemia (Divers and Peek, 2007; Smith, 2009a; Lorenz et al., 2011).

Bovine Viral Diarrhoea may occur at any age. The implicated virus causes immunosuppression and may act in synergy with other intestinal or respiratory pathogens, thereby increasing the mortality rate in the herd (Dieguez et al., 2009). Methods are available and have proved that BVDV infection in a dairy herd can be eradicated even at a regional and country level (Lindberg et al., 2006; Heffernan et al., 2009) resulting in a decreased incidence of calf diarrhoea (Ridpath, 2010). Persistently infected calves (PI) are usually weak and immunosuppressed and will be continuously affected by disease (Ridpath, 2010). When identified, PI animals should be culled or euthanised as they are important and permanent shedders of virus (Divers and Peek, 2007).

*Salmonella* spp., mainly *S. dublin* and *S. typhimurium* can affect calves usually between 2 and 6 weeks of age. The pathogen is introduced into the herd via infected feed, water, pastures, cattle or humans or via other animals entering the herd. Episodes of salmonellosis among calves often occur in combination with outbreaks of clinical problems in the dairy herd of origin, in particular when housed together. Other strains (e.g. *S. enteritidis*) may cause outbreaks if poultry have access to calves or calves' feed (Stilwell, 2007). Calves are infected orally and clinical signs are severe depression, fever, respiratory distress and a bloody/fibrinous diarrhoea. Pneumonia and gangrene of distal extremities (especially of feet, tail and ear tips) are frequent in *S. dublin* infection. The peracute evolution will show very few clinical signs of disease due to sudden death (Mohler et al., 2009). Routine use of antimicrobials to control other pathogens (e.g. *E. coli*) can help establish multidrug-resistant *Salmonella* that may persist in bedding material (Cobbold et al., 2006; Mohler et al., 2009). Multidrug-resistant strains of *Salmonella* are frequently implicated in disease outbreaks in calves and, occasionally, people.

Clostridial infections in the gastrointestinal tract are sometimes a problem in calves. Affected calves exhibit tympany, haemorrhagic abomasitis and abomasal ulceration (Smith, 2009a; Van Kruiningen et al., 2009; Van Immerseel et al., 2010). As yet, relatively little is known about the aetiology apart from the participation of *C. perfringens* type A. These bacteria were the most prevalent (85 % of herds) in a Dutch study looking at microorganisms in faeces, but no managerial factor was associated with shedding (Bartels et al., 2010). Overfeeding or feeding that decreases gut motility is suggested to contribute to the occurrence of the disease (Smith, 2009a). Other species (*C. difficile*) and types of *C. perfringens* have been identified in enteric disease in calves.

Coccidiae (*Eimeria* spp. and *Isospora* spp.) are intracellular protozoan parasites that are frequently identified in cattle. In Europe, the distribution and species prevalence may differ from country to country. Svensson (1993) found a predominance of *E. alabamensis* in Swedish dairy calves. The prevalence of *E. bovis* and *E. zuernii*, 77 % and 83 % respectively, showed that these pathogenic coccidiae were ubiquitous in German cattle populations and an important cause of diarrhoea in calf rearing units (Bangoura et al., 2011). In Estonia (Lassen et al., 2009) and England/Wales (Stewart et al., 2008a), the main species identified in calves were also *E. bovis*, *E. zuernii* and *E. ellipsoidalis*. In Greece, coccidian oocysts were found in 47 % of the samples of calves' faeces (Theodoropoulos et al., 2010). In Austria, the most prevalent is coccidiosis which affects calves over 3 weeks old and up to 12 months of age (Divers and Peek, 2007; Radostits et al., 2007; Smith, 2009a). Overstocking on pasture and overcrowding indoors, poor sanitation and hygiene, and stressors such as a very cold or very hot climate, are important risk factors (Radostits et al., 2007; Bangoura et al., 2011). Clinical signs commonly occur following weaning and introduction into the feedlot (Radostits et al., 2007). Infection may be sub-clinical but acute and sub-acute diarrhoea (sometimes with blood) can occur, usually as a result of exposure at the first grazing season in areas contaminated with oocysts (Smith, 2009a). Usually, there is loss of weight, and mortality may be high, particularly when combined with other stressors, such as underfeeding or other diseases.

*Cryptosporidium* spp. are intracellular protozoan parasites belonging to the Coccidiae family. Two species are distinguished: *C. parvum* and *C. andersoni*, although only *C. parvum* has been shown to be associated with diarrhoea in calves under the age of 3 months (O'Handley and Olson, 2006). Oocyst shedding occurs as early as 3 days of age, peaks at 2 weeks of age, and can continue to occur in adult cattle (O'Handley and Olson, 2006; Wyatt et al., 2010). Infection has been shown to induce severe villous atrophy (Foster and Smith, 2009) that will cause prolonged malnutrition. Cryptosporidial infection in calves less than 30 days old is significantly associated with the risk of infection in the dairy herd. *Cryptosporidium* may occur in 30-50 % of diarrheic calves on a worldwide basis (Radostits et al., 2007). Rotavirus and *Cryptosporidium* were the most commonly detected enteropathogens in diarrheic samples in Norway (Gulliksen et al., 2009a). Oocysts have been identified in herds with and without diarrhoea problems (Silverlås et al., 2010). Since severity and incidence of clinical disease in infected calves is very inconsistent within and between farms, there are some authors that question if *C. parvum* is really a primary pathogen (Foster and Smith, 2009). The risk of clinical disease increases when animals are grouped together and when hygiene and management practices are deficient (Trotz-Williams et al., 2007; Szonyi et al., 2012). Factors associated with a decreased risk of infection in pre-weaning calves were shown to be ventilation of calf rearing areas, daily addition of bedding, feeding of milk replacer, daily disposal and cleaning of bedding and the use of antibiotics. In addition, post-weaning movement of animals was also associated with a decreased risk of infection with *C. parvum* (Wyatt et al., 2010; Szonyi et al., 2012).

Another protozoan potentially related to enteric disease is *Giardia duodenalis*. Although very high prevalences have been found in adult and young cattle (Maddox-Hyttel et al., 2006) infected animals do not show clinical signs. However, *Giardia* spp. have been suggested as an important production-limiting parasite (O'Handley and Olson, 2006).

#### 4.3.9.3. Respiratory disease

New information is added and text from Section 10.2. of the EFSA Opinion (2006) is updated.

Although there is a very distinct difference in the epidemiology of pneumonia of beef (suckler) calves and dairy calves raised for veal, there are common features, and so a cross-reference with the beef cattle Chapter is recommended.

The most common bacterial pathogens in calves with respiratory disease are *Pasteurella multocida* and *Mannheimia haemolytica* (Griffin et al., 2010). These agents are usually found in the bovine nasopharynx and may, as a result of viral disease proliferate, colonise the lungs of the calf. *P. multocida* was shown to be the most prevalent respiratory pathogen in 40 herds (Autio et al., 2007).

The respiratory disease affecting calf-rearing units is usually insidious, since it seems to be continuously present in a farm and does not occur in isolated outbreaks. It is generally designated as enzootic pneumonia (Radostits et al., 2007) and is the most common respiratory disease in cattle ascribed to *P. multocida* (Griffin et al., 2010). Enzootic pneumonia usually affects calves between 1 and 6 months of age (Radostits et al., 2007) and is a typical multifactorial disease, with infectious, individual and environmental factors as important components (Woolums et al., 2009). It is caused by a variety of different types of microorganisms, which are always present but they become a nuisance only with additional contributory factors (Griffin et al., 2010). The signs usually found are fever, nasal discharge, coughing and increased respiratory sounds when lung auscultation is performed. Fever may not be present, particularly in chronically affected animals or those that are also dehydrated.

Diagnosis of aetiological factors may be achieved from serological examinations, viral examinations from nasal discharge, broncho-alveolar lavage (BAL) or at necropsy. The most important infectious agents are viruses (IBR, BRSV, Pi3, BCoV and BVD; Lazic et al., 2009) and bacteria (*Pasteurella multocida*, *Histophilus somni*, *Mycoplasma bovis*, *M. haemolytica* and others; Confer, 2009; Griffin et al., 2010).

Bovine respiratory syncytial virus (BRSV) is an agent present worldwide that occurs with seasonal peaks during autumn and winter. BRSV infects the upper and lower respiratory tract and is shed in nasal secretions. The bovine virus is closely related to the human respiratory syncytial virus (HRSV; Brodersen, 2010). The virus is thought to be transmitted from infected animals by human or airborne transmission. Morbidity can be high but mortality is usually low. Fever as high as 40 ºC, coughing, nasal discharge and tachypnea are the most common clinical signs. Incubation varies between 3 and 9 days. Vaccination is efficient (Brodersen, 2010)

Another virus with a milder course of disease is Para-influenza-3 virus. PI-3 is a long recognised, but underappreciated, endemic infection of dairy and beef calves. Clinical disease is most common in calves with low maternal antibodies. Clinical signs are fever, nasal discharge, and dry cough. This virus can cause immunosuppression that predisposes to secondary bacterial infections (Ellis, 2010).

Infectious Bovine Rhinotracheitis (IBR) is caused by a herpesvirus (BHV-1) and, although it only affects the upper respiratory tract, it facilitates access to the lung by bacteria (Jones and Chowdhury, 2007). Passive immunity will protect calves for up to 4 months and so it is not an important agent for young animals if dams have been infected or vaccinated, and colostrum has been correctively administered.

BVD is a Pestivirus and its role in respiratory disease is one of synergism with other viruses or bacteria, due to its immunosuppressing activity.

Bovine coronavirus (BCoV) has been implicated in respiratory disease in some herds but its importance is still not known (Decaro et al., 2008)

In Hungary, only 5 % of BRD calves were positive for *H. somni* (Szeredi et al., 2010). Along with respiratory disease, it is also responsible for meningitis (TEME) and arthritis (Radostits et al., 2007; Booker et al., 2008; Fulton et al., 2009; Griffin et al., 2010).

*Mycoplasma* spp. have been found to cause severe pneumonia as well as other diseases, such as otitis and arthritis. Chronic caseonecrotic bronchopneumonia, with or without arthritis, is the lesion most reliably known to be caused by *M. bovis* (Caswell et al., 2010). The role of *M. bovis* in respiratory disease remains controversial, as it has been isolated from healthy and BRD-affected animals. However, a study in veal calf farms in France showed *M. bovis* to be the most prevalent agent in respiratory disease outbreaks, spreading early and widely throughout the affected units (60-100 % rate of isolation and seroconversion; Arcangioli et al., 2008). In contrast, other studies did not find *M. bovis* in any of 40 farms investigated (Autio et al., 2007).

*Arcanobacterium pyogenes* and *Staphylococcus aureus* are secondary agents mostly found in chronic cases (Confer, 2009; Griffin et al., 2010).

It has been shown that none or few of these microorganisms will cause severe disease if the other components (host and environmental) are not present (Griffin et al., 2010). Stress from weaning, co-mingling mutilation, transport and diet changes are major causes of immunosuppression. Clinical experience shows that the incidence and prevalence of infectious respiratory disease is much higher in rearing systems where the calves have been bought and transported from several farms than if they are reared on the farm on which they were born (George Stilwell, FMV-UTL, personal communication, January 2012). A recent study (Pereira, 2011) measuring blood and salivary cortisol in young calves entering a fattening unit showed very high cortisol in calves in the first 24 hours compared with levels

8 days later. Hodgson et al. (2005) demonstrated that stress significantly altered the viral-bacterial synergy and resulted in fatal BRD.

Undernutrition or poor quality milk will also lead to a state of immunosuppression, especially in cold weather, and consequently to a higher susceptibility to infectious pneumonia.

Environmental factors predisposing to respiratory disease are lack of ventilation, high animal density, extreme temperatures and high relative humidity. Several studies have shown that calves reared indoors commonly develop more complex respiratory disease. Housing calves in groups of 10 or less, where their feed has been calculated by computer, results in improved growth and less morbidity associated with respiratory disease (Svensson and Liberg, 2006). This agrees with findings in a recent survey among farms for white veal in France, Italy and The Netherlands, showing that the risk of respiration difficulties at the beginning of the fattening period (3 weeks after arrival of the calves at the fattening unit) increased with increasing group size (Brscic et al., 2012). Keeping animals with a history of respiratory disease separated from those never affected, minimised the future incidence in this latter group (Bach et al., 2011). Inadequate ventilation increased the risk of respiratory disease. Ammonia (levels > 20 ppm) and other gases will destroy the mucociliary epithelium, allowing access of bacteria and viruses to the lower respiratory tract (Woolums et al., 2009).

In addition to group size, the survey of Brscic et al. (2012) also identified the average weight of a batch of calves on arrival at the fattening unit as a risk factor for respiratory difficulties at the beginning of the fattening period. Calves that arrived at the fattening unit with lower weights (< 43 kg on average) showed a higher risk of difficult respiration compared with the heavier ones (> 51 kg on average). Possibly, lightweight calves represent animals with a reduced condition and a compromised immune capacity.

#### 4.3.9.4. Other diseases

New information is added and text from Section 10.3. of the EFSA Opinion (2006) is updated.

Ulcers

Non-perforating abomasal lesions are a considerable problem affecting more than half the population of veal calves (Brscic et al., 2011). Ulcers can be chronic or acute and are more usual in calves from 1 to 6 months of age. Clinical history and examination will reveal abnormal faeces, unthrifty, mild to moderate abdominal distension and pain, fluid-splashing sounds over the right flank and mild dehydration (Smith, 2009a). A study comparing the prevalence of abomasal lesions in Swiss veal calves from conventional or farms with higher animal welfare standards showed that animals raised in the conventional farms had higher prevalence of lesions. The authors identified the risk factors as no access to an outside pen, missing access to water, straw as the only roughage and feeding by bucket (Bähler et al., 2010). Brscic et al. (2011) also found fewer lesions in veal calves kept in welfare-friendly installations (e.g. higher space allowance and use of heating).

Omphalitis and complications

Infections may occur in the umbilical cord of newborn calves (Radostits et al., 2007). Various bacteria are found and, through a bacteraemia, infection may spread to the joints, meninges and internal organs (Radostits et al., 2007). Omphalitis is painful in response to palpation of the umbilicus. Arthritis is often secondary to an umbilical infection and usually affects the calf during the first month, resulting in warm and swollen joints, fever and lameness (Radostits et al., 2007; Smith, 2009a). Disinfection of the umbilical cord soon after birth and/or closing the umbilicus by tying it with string, are good management practices that reduces the occurrence of omphalitis, phlebitis, liver abscesses, polyarthritis, meningitis and septicaemia. All these conditions can cause pain, discomfort, depression, recumbence and even lead to death.

Young animals (under 2 weeks of age), especially those immuno-compromised due to failure of passive immune transfer, are particularly susceptible to septicaemia and bacteraemia. Calves exposed to very virulent agents, such as *Escherichia coli* (and other coliforms) or *Salmonella*, will show severe signs of septicaemia such as depression, lack of a suckling reflex and fever, followed by dehydration, prostration, shock, coma and death. The source of pathogenic bacteria is often the contaminated environment and this may occur at the time of parturition (Fecteau et al., 2009).

Meningitis is a common complication of septicaemia and bacteraemia. Animals are lethargic followed by lateral recumbency, and neurologic signs (convulsions, opisthotonus, head and neck nystagmus, tonic-clonic seizures; Radostits et al., 2007; Fecteau et al., 2009). Hyperaesthesia is common and spinal reflexes are often exaggerated.

*Histophilus somni* and *Mycoplasma* sp. may cause arthritis and otitis associated with respiratory disease

### 4.3.10. Therapeutic strategies including antimicrobial use

New information is added and text from Section 10.5. of the EFSA Opinion (2006) is updated.

The most important component of a diarrhoea treatment protocol is rehydration (Berchtold, 2009). Fluids and electrolytes should be given in all cases of enteric diseases and in certain other diseases, such as pneumonia (Lorenz et al., 2011). Glucose and alkalinising products (e.g. sodium bicarbonate, sodium acetate) are also essential in most cases of diarrhoea. Oral electrolyte solutions are generally enough in mild cases but in severe cases (dehydration above 8 %) parental fluid therapy should be instituted (Berchtold, 2009; Sen et al., 2009; Smith, 2009a; Coskun et al., 2010). There are no specific treatments for viruses or cryptosporidiosis and, therefore, control of dehydration is the only approach for this type of diarrhoea.

Although the use of antibiotics as growth promoters is restricted through EU legislation, they are still used in large quantities in calf rearing for both prophylactic and therapeutic purposes. In those instances where calves are not reared on site but transported to other locations and mixed in groups, the incidence of clinical illness is high and the use of antibiotics is frequent (Rerat et al., 2012). The routine use of antimicrobials in the milk fed to calves increases the incidence of multi-resistant strains (DeFrancesco et al., 2004; Rerat et al., 2012) and calves' morbidity and mortality in the long-term (Berge et al., 2009b). Davis et al. (2007) found more antimicrobial resistance in *Salmonella dublin* isolates from dairy farms than from beef herds. A recent study also demonstrated more resistant strains of *E. coli* and resistance to more antimicrobials in milk-fed veal calves compared with grain-fed veal and beef cattle (Cook et al., 2011). It was shown that *E. coli*, *Salmonella* and *Campylobacter* antimicrobial resistances, and calf morbidity and mortality were reduced when oxytetracycline use in milk was stopped and replaced by adequate colostrum management (Berge et al., 2005; Kaneene et al., 2008). Therefore, the ability to use antibiotics only for clinical treatment of disease is important to decrease morbidity and mortality even further. In order to minimise prophylactic use of antibiotics, adequate passive transfer of colostrum needs to be assured. Furthermore, measures need to be taken to optimise colostrum consumption, nutrition, decrease environmental stressors and the pathogen load on farms. The use of rearing systems for calves that increase the incidence of disease and thus the use of antibiotics for either preventive or clinical purposes should be avoided.

The use of antimicrobials to treat clinical illness will improve the welfare of the animal when the drug has a beneficial clinical effect. Antimicrobials should be used in respiratory disease and other diseases with a bacterial origin, but they are only recommended for calves with diarrhoea that have signs of systemic illness (Constable, 2004; Radostits et al., 2007). To guide the use of antimicrobials and other preventative measures, there should be continuous monitoring of the disease situation based on laboratory examination of appropriate specimens, from autopsies of dead animals to diagnose the pathogens, and sensitivity tests for the bacterial pathogens. Once started, an antibiotic protocol should not be changed before the third day of treatment. Early treatment and first treatment success in cases of calf pneumonia are crucial, since the outcome for those animals that fail to respond successfully to first treatment is very poor (chronic pneumonia; Lorenz et al., 2011). However, the frequent use of antibiotics results in increasing resistance in bacteria such as *E. coli*, and thus poses a threat to the welfare of calves, as well as humans, in the longer term.

Septicaemia, bacteraemia and meningitis should be treated with antibiotics but in all these conditions analgesic (NSAID) treatment is advisable, including sedation in case of meningitis. Also crucial is supportive treatment that will improve the success rate and welfare, such as administration of intravenous fluids and oral or parenteral nutrition. Appropriate nursing care should be provided and emphasised to the client or the calf caretaker. Optimal temperature (not too cold or too warm) and ventilation are important as well. In the case of prolonged lateral recumbency, ulcerations around joint areas are frequent and are prevented by appropriate bedding (deep straw). Faecal material needs to be washed from the perineum regularly to prevent accumulation and myiasis. Eyes of laterally recumbent animals should be protected by a film of ointment, checked repeatedly for corneal ulcers, and washed and treated as appropriate. Regular changes of an animal's lateral position are very important to prevent musculoskeletal, skin and eye lesions (Fecteau et al., 2009).

Non-steroidal anti-inflammatory drug (NSAID) therapy will reduce pain and discomfort and may increase food intake and weight gain in diseased animals (Philipp et al., 2003; Todd et al., 2010).

On-farm humane killing is a requirement for the welfare of severely distressed, injured, or moribund calves (Stull and Reynolds, 2008). The only acceptable methods for euthanasia of calves are an overdose of general anaesthetic (such as barbiturates), captive bolt or gunshot. An on-farm killing (euthanasia) programme should be created by a veterinarian and should include teaching of stockpersons to recognise calves that are candidates for euthanasia, and appointment and training of specific personnel to perform it.

### 4.3.11. Control and management of diseases in calves

New information is added and text from Sections 9.1 and 10.1 of the EFSA Opinion (2006) is updated.

A welfare programme keeps calves healthy by preventing disease, by identifying sick calves early and providing correct diagnosis and treatment (Stull and Reynolds, 2008). These authors recommend that this welfare programme should include the training of employees to perform tasks such as vaccinations, treatments, dehorning, and euthanasia; daily observations of calves for disease and injuries and daily observations of facilities for repair needs to prevent injuries and maintain sanitation. Vaccination and treatment protocols should be reviewed regularly to determine that they exist, have been developed with veterinary advice, and are being practised.

Identifying sick animals in the early stages of disease is a crucial element for therapeutic success. This is achieved by frequent and competent observations of groups and individuals. Detection of more than 85 % of sick animals can be achieved by twice weekly faecal scoring of all calves under 2 weeks of age (McGuirk, 2008). When automatic milk feeders are used, the number of visits to the feeder may help identify diseased animals (Svensson and Jensen, 2007). Control of diseases is also reinforced by early treatment and isolation of sick animals.

Methods to control enteric diseases in calves include proper housing and hygiene and good colostrum management. Colostrum quality, quantity and time of administration have all been shown to influence the transfer of immunity to calves. Cows vaccinated during the dry period against the specific enteric pathogens enterotoxigenic *E. coli*, coronavirus, rotavirus, and *Clostridium perfringens* types C and D, will yield high quality colostrum and consequentially guarantee better health and welfare of calves. A study has found that calves vaccinated against the above agents also shed less *Cryptosporidium parvum* oocysts (Adjou, 2011)

Salivary secretions from sick calves can transmit *Salmonella* sp. and other enteric pathogens, making the disposal of refused milk, water, and feed away from the calf environment an essential aspect of disease management (McGuirk, 2008). Adding clean and dry bedding and the removal of all feed refusals from the calf housing area are two very effective ways to control potential enteric pathogens. Having 10 % more calf pens than calves at maximum occupancy provides time for cleaning, sanitising, and using resting pens between successive occupants (McGuirk, 2008), thereby reducing exposure to infectious agents.

Milk replacer and pasteurised milk are less dangerous to calves provided that mixing, storing, delivery and the equipment used are dealt with in a hygienic way. In a study with pasteurised milk given to calves, it was concluded that milk handling after pasteurisation was a very important issue and in some cases bacterial counts in milk fed to calves were similar to pre-pasteurisation levels (Elizondo-Salazar et al., 2010). Whole milk that has not been pasteurised can present a high risk for enteric infection particularly if not fed immediately or, alternatively, has not been chilled. Feeding raw waste milk is a risk factor for *Mycobacterium bovis*, *Mycoplasma bovis*, parasites and other infectious agents (Callan and Garry, 2002). Lesser risks for spread of enteric pathogens are aerosolisation and self-grooming (McGuirk, 2008).

There is little scientific basis for safety, efficacy, or disease protection of young calves by vaccination. In addition, maternal antibodies may interfere with acquired immunity after vaccination in very young calves (e.g. BVD, *M. haemolytica*, *P. multocida*; Cortese, 2009).

Halofuginone lactate is used as a prevention measure for *C. parvum*, but studies have shown that efficacy is only proven when in combination with regular cleaning and disinfection of rearing equipment, good ventilation of calf housing, rearing animals in clean individual pens, providing bedding with a thickness of 10-15 cm, prompt separation of newborn calves from their mothers and keeping calves in same-age groups (Lallemand et al., 2006; Schelcher et al., 2008; De Waele et al., 2010). Diarrhoea caused by *C. parvum* can be prevented with an appropriate supply of immune colostrum (Wyatt et al., 2010).

The individual calf hutch placed in an outdoor environment can provide a good environment for the prevention of respiratory and other diseases of calves (Woolums et al., 2009; Gorden and Plummer, 2010) but deprives the calves of social contact. Avoiding overstocking is an important management measure that reduces disease incidence and limiting group size in both unweaned and weaned calves to groups of less than seven has been shown to result in the best overall welfare for calves (Svensson and Lieberg, 2006; Gulliksen et al., 2009c; Griffin et al., 2010; Torsein et al., 2011).

Calves in separate pens prevented from social contact with their neighbours by a solid barrier are clearly deprived of social contact and make efforts to have such contact. However, there can be a disadvantage to calf welfare caused by greater spread of disease as a result of close contact, particularly in overstocked and inadequately ventilated housing or during an outbreak of respiratory disease. Disease can be spread within buildings by short-range airborne transmission of droplets, longer-range aerosol transmission, direct contact and vectors (e.g. buckets, stockpersons). Different scientific studies have given different emphasis to these different routes (e.g. Wathes et al., 1988; Gorden and Plummer, 2010). Recent results indicate a role of direct contact for the transmission of respiratory disease and hence the importance in disease control of decreasing direct contact between calves within the same building by means of solid walls (Lago et al., 2006). However, in this study, the number of calves studied in detail was small (225 of which 32 had respiratory disorders) and factors such as ventilation quality and age of neighbours could have accounted for some of the results. Solid dividers and deep-straw bedding increased airborne counts in the study but bedding reduced heat loss in cold weather. The suggestion by Gorden and Plummer (2010), that there should be solid dividers between calves, but an open front and rear of the area be maintained where possible, could be useful when there is an outbreak of respiratory disease but, because of the positive effects of group-rearing and social contact after a few days of age, this should be regarded as an emergency action rather than a desirable routine strategy.

Keeping calves in stable groups, as opposed to dynamic groups, where new calves are continuously introduced or removed, and grouping animals of similar age lowers the risk both for diarrhoea and respiratory disease (Gulliksen et al., 2009b ; Pedersen et al., 2009). If calves from different farms are put into the same building without a means of preventing pathogen spread, the risk of disease will be high for all the calves.

Prevention practices associated with respiratory disease control in calves include the development and maintenance of a robust immune system through delivery of adequate good-quality colostrum, sound nutrition, proper vaccination, biosecurity, and provision of adequate ventilation (Gorden and Plummer, 2010). Many authors consider the adequate management of good quality colostrum as the most important measure to decrease morbidity and mortality from infectious diseases (Cortese, 2009; Stilwell et al., 2010; Lorenz et al., 2011).

Navel disinfection (e.g. repeated cord dipping with chlorhexidine or iodine) can play an important role in controlling diseases in new-born calves. It was shown to reduce the number of calves needing treatment for respiratory disease from 19 % to 5 %, and decrease calf mortality by half (McGuirk, 2008; Gorden and Plummer, 2010). Tying the navel is also an efficient method for reducing access of microorganisms (McGuirk, 2008; George Stilwell, FMV-UTL, personal communication, January 2012), although it may prevent drainage in case of infection. In contrast, Mee (2009) suggested that producers should avoid potentially harmful cord procedures and concentrate on maternity pen hygiene and calf immunity instead.

When using individual calf hutches these should be situated where weather effects are minimal and away from objects that can contaminate the calf's environment, such as building exhaust fan vents, manure or runoff from other farm buildings. Hutches should be placed at least 1.22 m apart and thoroughly washed and disinfected between use (Gorden and Plummer, 2010). Ideally, hutches should be moved between groups to minimise bacterial contamination of the surface beneath the hutch (Callan and Garry, 2002). Routine and daily management procedures should be ordered to ensure that animal contact is from younger to older calves. Stockpersons should disinfect clothes, hands and boots before entering buildings with young calves, particularly when they have been working with older animals (Gorden and Plummer, 2010). However, individual hutches do not allow normal social interactions to occur and the negative welfare consequences have to be set against any reduction in pathogen transmission.

Barns that are being prepared to house unweaned calves in individual pens should be planned to provide each calf with an area of at least 2.2 to 3 $m^2$ (Lago et al., 2006; Maunsell and Donovan, 2008). Pens should have bedding material that ensures the calves' comfort even in periods of cold stress. A ventilation system inside barns may help improve the air quality enough to provide disease control similar to calf hutches (Nordlund, 2007).

Calves with a previous history of respiratory disease should not be kept with calves with no history of respiratory disease.

In summary, an adequate control of disease in calves is based on: (1) early identification of sick animals, (2) removing the source of infection, (3) removing calves from the contaminated environment, (3) increasing the non-specific immunity of the calf, (4) increasing the specific immunity of the calf, and (5) reducing stress (Radostits et al., 2007; Mohler et al., 2009; Lorenz et al., 2011).

***Conclusions***

1. Ensuring good welfare in calves requires good management, and an environment that fulfils the needs of the animals, including the need to avoid disease. Prevention of typical calf diseases in the first 6 months of life, such as diarrhoea and bovine respiratory syndrome, requires a systematic approach by improving management and housing conditions, specifically the preparation of the cow, hygiene of the calving environment, including dry, clean bedding and high air quality, immediate

supply with maternal antibodies, putting calves from different sources in different air-spaces, no mixing with older animals, and careful attention with a rapid response to any sign indicating disease.

2. Identifying sick animals in the early stages of disease is a crucial element for therapeutic success. Environmental factors predisposing to respiratory disease are lack of ventilation, high animal density, extreme temperatures and high relative humidity.

3. Calves that do not get good quality colostrum after birth are more susceptible to respiratory disease at the feedlot.

4. Non-perforating abomasal lesions affect more than half the population of veal calves. There are less of these lesions in veal calves kept in welfare-friendly installations.

5. Infections may occur in the umbilical cord of newborn calves, leading to bacteraemia and infection of the joints, meninges and internal organs.

6. The average weight of calves upon arrival at the veal farm may be a risk factor for respiratory disease during the early stages of the fattening period. Light-weight-calves may be more at risk than heavier ones.

***Recommendations***

1. For the major enteric and respiratory infections, supportive treatments including oral or parenteral rehydration and systemic analgesia (NSAID) should be provided.

2. Calves from dairy farms should get an adequate quantity of colostrum at the most appropriate time.

3. After receiving adequate colostrum and separation from their dams, artificially-reared calves should be housed in group pens that permit social contact when there is a low risk of enteric and respiratory disease. When the disease risk is high it may be necessary to isolate calves from contagion or short-range airborne infection until early weaning at 4-6 weeks or entry into a unit rearing calves for white veal. However, there should be no compensation for bad management of calves, such as the mixing of groups of calves from different sources, by individual housing.

4. An on-farm humane killing (euthanasia) programme is a requirement for the welfare of severely distressed, injured, or moribund calves. This programme should be created by a veterinarian and include teaching of stockpersons to recognise calves that are candidates for euthanasia and appointment, as well astraining of specific personnel to perform it competently.

5. Frequent and competent observations of groups and individuals, including faecal scoring and early treatment and isolation of sick animals, are necessary to control diseases in calves.

6. Navel disinfection or ligature should be performed in calves born in pens (dairy calves), when needed for hygiene reasons.

7. The condition and immunocompetence of calves should be improved upon arrival at intensive fattening units, for example, by taking heavier-weight calves. More research is required into effective strategies to enhance the condition, immunocompetence and “robustness” of calves in general upon arrival at the fattening unit.

## 4.4. Calves kept in intensive farming systems: risk assessment conclusions

### 4.4.1. Introduction

The most important risks to the welfare of calves in intensive farming systems are presented in Table 7. These have been extracted from the complete risk assessment exercise. The methodology and full results of risk assessment are presented in Appendix 2.

The hazards included in Table 7 were selected on the basis of the magnitude of the adverse consequence (intensity x duration) and the probability of occurrence in the population (probability of adverse consequence when exposed to the hazard x probability of exposure within the population).

The inclusion criteria for this list of main hazards were those hazards that had a very high magnitude with a probability equal to or higher than 2 % and those with a high magnitude and a probability equal to or higher than 10 %.

**Table 7:** Calves kept in intensive farming systems: risk assessment main outcomes.

| TARGET POPULATION: Calves | | | | | Risk Assessment | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Hazard identification | | | Risk characterisation | | | | |
| Section | Sub-section | Welfare outcome | Hazard description | Hazard specification | Magnitude | Probability of the event ML | CI5% | CI95% | Uncertainty |
| **Housing** | | | | | | | | | |
| | **Flooring and bedding material** | Discomfort | Type of floor | Slatted flooring (concrete) | High | 21% | 17% | 26% | Medium |
| | | | | Wooden slats | High | 48% | 40% | 57% | High |
| | **Temperature, ventilation and air hygiene** | Heat stress | THI > 78 | Wind < 0.5 m/s | High | 16% | 11% | 22% | Medium |
| | | Respiratory disease | Air volume | Air volume per animal < 10 $m^3$ | Very High | 10% | 6% | 15% | High |
| | | | Air quality | Ammonia > 20 ppm | Very High | 2% | 1% | 4% | High |
| | **Degree of social contact** | Respiratory disease | Group size | < 6 animals per group | Very High | 17% | 11% | 25% | High |
| | | | | > 15 animals per group | Very High | 6% | 4% | 10% | High |
| | | Disturbed resting behaviour | Space allowance | < 1.5 $m^2$/animal | High | 47% | 35% | 59% | Medium |
| **Feeding and housing systems, weaning strategies and quality of solid and liquid feed** | | | | | | | | | |
| | **Feeding systems** | Disturbed glucose metabolism | Low feeding frequency milk replacer during fattening | Twice daily | High | 21% | 18% | 24% | High |
| | | Diarrhoea | High levels of milk replacer during fattening | | High | 23% | 16% | 33% | Medium |
| | | Poor body condition | No proper standardisation of calves within pens based on BW and drinking speed during fattening | | Very High | 5% | 3% | 10% | High |
| | | Dehydration or thirst | Restricted amount of water next to milk replacer during hot weather or disease during fattening | | High | 10% | 5% | 16% | High |
| | **Feeding pre-weaning** | Health problems | Inadequate colostrum | | Very High | 17% | 11% | 24% | Medium |
| | | | Contaminated colostrum | Septicemia and other diseases | Very High | 6% | 4% | 8% | High |
| | | | Low quality liquid feed | Vegetable protein | High | 11% | 4% | 18% | High |
| | **Quality of solid and liquid feed (white veal)** | Clinical signs of anaemia, Hb < 4.5 mmol/l | Restricted dietary iron supply during fattening | Iron < 50 ppm | Very High | 17% | 9% | 30% | Medium |
| | | Health problems | Restricted solid feed supply next to milk replacer during fattening | < 500 g DM/animal/day | Very High | 16% | 9% | 27% | Medium |
| | | Digestive system disorders | Unbalanced solid feed next to milk replacer | Roughage < 25 % of DM | Very High | 19% | 12% | 29% | Medium |
| | | Abnormal oral behaviours | Restricted and unbalanced solid feed next to milk replacer during fattening | | High | 16% | 11% | 21% | Medium |
| | | Digestive system disorders | Low quality milk replacer during fattening | Too much vegetable protein | Very High | 24% | 19% | 30% | High |
| | **Nutrition and feeding** | Digestive disorders: | | | | | | | |
| | | Abnormal oral behaviours | Restricted and unbalanced solid feed next to milk replacer during fattening | | High | 24% | 20% | 29% | Medium |
| **Disease and management** | | | | | | | | | |
| | **Monitoring of Hb and treatment with iron (white veal)** | Clinical signs of anaemia, Hb < 4.5 mmol/l | Inaccurate monitoring of iron status - haemoglobin | Only at the beginning and in the middle of fattening period, group-wise rather than individually | High | 12% | 9% | 15% | Medium |
| | **Composition of calf batches** | Disease | Calves from different farms and/or countries | | Very High | 79% | 72% | 85% | High |
| | | | Light weight on arrival | < 45 kg | Very High | 3% | 2% | 4% | Low |
| | **Group composition** | Disease | Rotation of calves across pens - standardisation of BW and drinking speed | | Very High | 18% | 14% | 22% | Medium |
| | **Management** | Omphalitis, septicemia, polyarthritis | No umbilical disinfection | | Very High | 2% | 1% | 4% | High |

### 4.4.2. Intensive calf farming systems risk assessment comparison

As in the previous EFSA Opinion on the risks of poor welfare of calves kept in intensive farming systems (EFSA, 2006), the hazards “Temperature, ventilation and air hygiene”, “THI above 78”, “Reduced air volume per animal” and “High amonia concentrations” had a high risk.

Besides these housing factors, “Group size” and “Inadequate type of floor” have also been identified as major risks for welfare.

Several factors related to “Feeding” and “Weaning strategies” have also been highlighted, namely those related to “Inadequate or contaminated colostrum intake”, “Inadequate milk replacer feeding practices” and “Lack of proper standardisation of calves within pens”.

As in the previous assessment (EFSA, 2006), “Restricted dietary iron supply during fattening”, “Lack monitoring of the consequent low haemoglobin” and “Treatment with iron” were factors considered to have a high risk.

“Group composition” was also one of the major hazards identified, in particular when resulting from “Mixing calves from different origins” and from the “Rotation of calves across pens without a proper standardisation based on body weight and drinking speed”.

It is necessary to highlight that the exposure assessment for most of the hazards had a high uncertainty.

It is recommended that exposure data, standardised to the underlying population, should be collected to support further welfare risk assessments.

## CONCLUSIONS AND RECOMMENDATIONS

*ToR: to consider if the conclusions and recommendations of the two previous Scientific Opinions were still valid (SCAHAW, 2001; EFSA, 2006).*

In order to update the scientific knowledge of the welfare of cattle kept for beef production, and the welfare in intensive calf farming systems, and, in particular, to consider if the conclusions and recommendations of the two previous Scientific Opinions (SCAHAW, 2001; EFSA, 2006) were still valid, new scientific evidence and data have been arranged following the table of contents and structure of the previous Opinions.

The conclusions and recommendations have also been ordered following the structure of previous Opinions.

The conclusions and recommendations of this Opinion have already been listed in each relevant section of the main text.

Additionally, in order to address the ToR and allow the reader to immediately link the conclusions and consequent recommendations of this Opinion with the previous ones, the following table has been developed to compare conclusions and recommendations regarding the welfare of beef cattle and intensively-reared calves, included in previous Opinions (SCAHAW, 2001 and EFSA, 2006) and in this Opinion.

The conclusions and recommendations of the two different Chapters of this Opinion (Chapter 3. BEEF CATTLE; Chapter 4. CALVES) have been kept separately in different relevant sections of the table.

The first column lists the conclusions and recommendations from the previous Opinions, SCAHAW (2001), for beef cattle, and EFSA (2006), for calves, with their relevant associated sections.

The second column lists the conclusions and recommendations following the present evaluation. In many cases, "no change" has been indicated or that the earlier conclusions and recommendations are supported by new evidence.

The conclusions and recommendations specified as supported by further evidence, additions or changes to the existing ones are identified with lthe etter "U" (update) before the numbers (updated conclusions: UC.1., UC.2., etc.; updated recommendations: UR.1., UR.2., etc.).

New conclusions and recommendations are identified with the letter "N" (new) before the numbers (new conclusions: NC.1., NC.2., etc.; new recommendations: NR.1., NR.2., etc.).

The third column identifies the relevant section in the text of this Opinion.

**Section 1: BEEF CATTLE**

| Beef Cattle | | |
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| **SCAHAW 2001 Scientific Opinion** | **This Scientific Opinion** | |
| | **New conclusions and recommendations following the present evaluation** | **Relevant section** |
| **The assessment of welfare (Section 2.2. of SCAHAW, 2001)** | | |
| ***Conclusions*** | | |
| 1. Cattle welfare can be assessed in a scientific way using a combination of methods. These methods include measurements of health, physiology, performance, and behaviour as well as preference tests, aversion tests, measures of motivation and abnormal behaviour. | No change | |
| 2. Welfare in existing systems can range from very good to very poor. The system of husbandry used can have a large impact on the welfare of the animals. | No change | |
| 3. Good welfare relates not only to the health of the animals but also to the ability to manage interactions with the environment and the existence of good feelings. | No change | |
| 4. The scientific assessment of welfare provides evidence on which to base recommendations for adopting or avoiding particular housing and management methods. | No change | |
| 5. Very young animals feel pain and show signs of distress, and may feel more pain than adults. | UC.1.<br>Additionally:<br><br>The amount of tissue affected by mutilations is usually greater in older animals, resulting in a more extensive area of pain and a more prolonged recovery. | 3.5.1.<br>Mutilations |
| 6. Very young animals may show a freezing response to fear and pain, and so may not show a co-ordinated flight response. | No change | |
| **State of the industry (Section 3. of SCAHAW, 2001)** | | |

| Conclusions | | |
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| 1. There is a large variety of climatic and farming conditions throughout the EU. Cattle production systems are partly based on the foodstuffs produced on farms. These foodstuffs are very dependent on the climatic conditions and as a consequence, fattening systems are very diverse. | No change | |
| 2. Within the EU there are 21.7 million dairy cows and 11.6 million beef cows. These animals are the source of cattle which will be accommodated in fattening units. | Update:<br><br>In 2010, the total cattle population within the 27 EU Member States was approximately 87.4 million, of which 23.1 million were dairy cows.<br><br>Not relevant to risk assessment | 3.2. State of the industry |
| 3. In 1999 the number of beef cattle fattened and slaughtered in the EU was 4.8 million heifers, 8.1 million bulls and 2.5 million steers. | Update:<br><br>In 2010, the total number of cattle slaughtered within the 27 EU Member States was approximately 21 million animals.<br><br>Not relevant to risk assessment | 3.2. State of the industry |
| 4. Large numbers of movements of live animals occur between countries. | Not relevant to risk assessment | |
| 5. The diversity of beef fattening systems in the EU is influenced by the different cattle breeds. These breeds may be dairy (primary output milk), dual purpose (produce milk and beef), or beef (primary output beef). The EU dairy herd is dominated by the Friesian/Holstein breed. In contrast, the EU beef herd is very diverse with late maturing beef breeds (e.g. Charolais, Limousin and Blonde d'Aquitane) as the predominant breeds in France. The beef herds in UK and Ireland consist largely of cross bred cows mated to late maturing beef breeds while beef breeds in Spain are predominantly local (rustic) breeds. | Not relevant to risk assessment | |
| 6. In mainland Europe the majority of male animals are fattened as young bulls. In the UK and Ireland the majority of male animals are castrated and are fattened as steers. | Not relevant to risk assessment | |
| 7. In mainland Europe the majority of young bulls are offered a | Not relevant to risk assessment | |

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| fattening diet based on maize silage plus concentrate. The duration of the fattening period varies with the type of animal and ranges from 120 to 250 days. The bulls from the dairy herd are slaughtered at 12 to 14 months of age. The bulls from the beef herd (weaned at 6 to 8 months) are slaughtered at 12 to 16 months of age. The demands of the market (carcass weight and conformation) determine the duration of feeding. | | |
| 8. In Ireland, UK and north western France where the males are fattened as steers, many of the animals are fattened off grass at 20 to 30 months of age and others are fattened indoors for their final 5 months on grass silage plus concentrate diet. Heifers surplus to breeding requirement can be fattened in intensive units or fattened off pasture at approximately 20 months of age. | Not relevant to risk assessment | |
| 9. Beef production in the USA is based mainly on steers and heifers from the suckling herds. Those animals are finished in feedlots with high energy diets. This farming system is very different to systems used in the EU. | Not relevant to risk assessment | |
| 10. Cattle production in the eastern European countries has declined in recent years | Not relevant to risk assessment | |
| | NC.1. The welfare of breeding suckler cows and bulls, and the welfare of unwanted male calves from the dairy herd are not considered in this Opinion but their welfare is an important subject for consideration.<br><br>Not relevant to risk assessment | 3.2. State of the industry |
| ***Recommendations*** | | |
| | NR.1. The welfare of breeding suckler cows and bulls and the welfare of unwanted male calves from the dairy herd are of significant scientific and public concern and they should be urgently addressed. | 3.2. State of the industry |
| **Housing Systems (Section 4. of SCAHAW, 2001)** | | |
| ***Conclusions*** | | |
| 1. There are a number of housing type options for fattening cattle including loose housing and tie up stalls. It appears that | No change | |

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| the vast majority of housed fattening cattle are accommodated in loose houses with slatted floors. | | |
| 2. Regulations on organic farming set a minimum indoor space requirement of 5m² for animals weighing over 350 kg, with a minimum of 1m² per 100 kg for animals over 500 kg | No change | |
| 3. The appropriate size of tie- stalls and cubicles is dependent on the size of animal. | No change | |
| 4. The surface recommended for littered loose houses or partially loose house is around 6 m² for 600 kg bulls and slightly lower for littered house with concreted feeding stand (6 to 4.5m²). | No change | |
| 5. Various studies have produced recommendations for slatted floor space allowance e.g. 2.2 to 2.5 m²/animal for cattle in the 550 to 650 kg liveweight range. These studies have been largely based on production considerations. | No change | |
| 6. Feeding trough space allowances for loose housed fattening cattle are in the range of 0.6 to 0.7 m per animal. | No change | |
| 7. Several types of handling equipment are in use depending partly on the type of animals for which they are used. The type of handling facility will depend on the size of the fattening unit and the tameness of the animals. | No change | |
| **Behaviour of cattle (Section 5. of SCAHAW, 2001)** | | |
| ***Conclusions*** | | |
| 1. Cattle have well developed senses and learning abilities. Although signs of pain may be less obvious in cattle than in other species, cattle have the ability to feel pain and neural mechanisms of pain perception seem to be similar in cattle and other animals, and humans. | No change | |
| 2. Cattle are highly social animals. Groups of cattle have a social hierarchy that determines priority of access to resources. Once established, the hierarchy tends to be stable and reduces fighting. Mixing of animals and housing animals in very large groups may disrupt the hierarchy and increase aggression. | No change | |
| 3. Cows form long-lasting bonds with their calves when allowed to do so. During natural conditions, weaning is a very slow | No change | |

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| and gradual process stretching over several months. | | |
| 4. Age at puberty depends on several factors, breed being important. Mounting may occur as a play behaviour well before puberty. | No change | |
| 5. Cattle are ruminant herbivores and although they can browse, cattle are mainly grazers. Cattle usually spend a long time grazing every day and show a distinct grazing pattern with maximum grazing activity around sunrise and sunset. | No change | |
| 6. Rumination may account for a substantial part of cattle activity. Rumination is under voluntary control and when animals are disturbed they cease to ruminate. | UC.2<br>Additionally:<br><br>Rumination time is primarily determined by the quantity of long fibre in the diet and, when diets are lacking in long fibres, normal rumination and salivation are greatly reduced and can lead to digestive disorders. | 3.5.3. Nutrition and feeding |
| 7. In most situations cattle drink several times a day, more in hot conditions. | No change | |
| 8. Cattle roam over extensive areas, and show a strong motivation to move. They also lie down for long periods. | Not relevant to risk assessment | |
| **Effect of housing on the welfare of the animals (Section 6. of SCAHAW, 2001)** | | |
| ***Conclusions*** | | |
| 1. Animals can cope successfully only within a range of temperatures and humidity. They are negatively affected when noxious gas levels are high. | UC.3<br>Change:<br><br>-Beef cattle can tolerate and adapt to a wide range of air temperatures.<br>-Metabolic heat production increases with increasing feed intake. Thus animals on the highest rations are least sensitive to cold and most sensitive to heat. Cold stress can be reduced by provision of appropriate shelter and a dry lying area. | 3.4.1. Thermoregulation, and cold and heat stress |
| 2. Insulation of buildings is an option which is used when the animals are housed on slatted floors and the outside temperature is very cold. As the volume allowances in such buildings are often low, a monitoring of the microclimatic environment and efficient ventilation devices are required. | UC.4<br>Change:<br><br>Adequate ventilation is crucial for cattle kept indoors especially in hot weather or when density is high. Adequate ventilation can be | 3.4.1. Thermoregulation, and cold and heat stress |

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| | achieved either by forced ventilation or well designed natural ventilation systems. | |
| 3. Tethered cattle have limited movement possibilities and cannot walk. Their social interaction is limited to their neighbours. Short tethers, low space and concrete floors are among the different factors limiting the comfort of these animals. Tethered animals have more leg problems than those on straw bedding. Hoof trimming is necessary for cattle tethered for long periods or those on excessively soft surfaces. | No change | |
| 4. A low space allowance increases aggression between animals especially among males. An increased occurrence of aggressive behaviour is also observed when the trough space is limited. | Supported by further evidence | 3.4.3. Space allowance and pen design |
| 5. Disturbances in the lying behaviour of animals are observed when the space allowance per animal is low. | Supported by further evidence | 3.4.3. Space allowance and pen design |
| 6. Diseases such as respiratory diseases are observed when the air volume or space allowance per animal is low. | Supported by further evidence | 3.4.3. Space allowance and pen design |
| 7. Daily gain seems to be less when the space per animal is lower then $4.7m^2$. | No change | |
| 8. The type of floor has important consequences for the welfare of the animals. When they have the opportunity, animals choose straw bedded areas for lying down in preference to slatted floors. | No change | |
| 9. Among the different types of bedding, lower mortality is observed in animals with at least some straw bedding and higher mortality in animals on completely slatted floors. | No change | |
| 10. Animals on sloped straw bedded areas have a higher incidence of lameness than animals kept on slatted floors. | UC.5<br>Change:<br><br>Animals kept on slatted floors have a higher incidence of injuries and abnormal movements when standing up and lying down than animals on straw or sloped straw-bedded areas. Partial rubberisation or rubber mats on concrete floors, especially for lying areas, | 3.4.4. Type of floor and bedding material |

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| | reduces the prevalence of lesions to claws and joints. | |
| 11. Tail tip necrosis occurs much more often on slatted floors than on other type of housing. | No change | |
| 12. The slat surface must not be slippery to avoid animals falling which increase the risk of health problems. | No change | |
| 13. Fattening cattle kept on concrete slatted floors have an increased incidence of abnormal postures, lesions to the carpal joint and to the tail, and may show behavioural changes. | No change | |
| 14. Increasing floor space allowance for animals on slatted floors improves growth rate and feed conversion ratio. | Supported by further evidence | 3.4.4. Type of floor and bedding material |
| ***Recommendations*** | | |
| 1. Cattle kept for beef production should not be tethered. Tethering increases the risk of health problems in the animals and limits their behavioural activities and social life. Exceptions could include temporary situations such as feeding or veterinary treatment. In this event particular care should be taken in the design and usage of the tethering system and the duration of tethering should be kept to a minimum. | No change | |
| 2. Group housing should be used wherever possible. | No change | |
| 3. The slope of the floor should not be too steep. The maximum slope should be 10% as steeper slopes may result in increased leg problems. | No change | |
| 4. a) Fully slatted concrete or wooden floors should not be used. Particular attention to the type of slats should be given to avoid slipperiness.<br><br>b) The gaps between the slats should not be so wide as to cause foot injuries, for example when claws become trapped. Slatted pens should only be used for animals of the size for which they were designed. A solid lying area with bedding is recommended although the use of rubberised slats may also provide for the animals' needs. | UR.1<br>a) Change:<br><br>Wherever possible cattle on slatted concrete should have access to a bedded area. Particular attention to the type of slats should be given to avoid slipperiness.<br><br>b) No change | 3.4.4. Type of floor and bedding material |
| 5. Animals should be provided with adequate floor space in | Supported by further reference | |

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| order to limit health problems and to ensure that the animals are not disturbed when lying. Increasing available floor space has been shown to improve animal welfare. For 500 kg animals these improvements are significant in the higher density ranges (1.5-3m² per animal) but have been little studied above 4m². The minimum space allowance should be 3m² for an animal expected to reach 500 kg plus or minus 0.5m² for each 100 kg difference expected between 400 kg and 800 kg. | | |
| 6. Handling and restraining facilities should be available in each unit. New handling facilities should be tested and approved. | No change | |
| 7. A sufficient number of separate pens should be available to accommodate sick animals. | UR.2<br>Additionally:<br><br>Farms regularly receiving animals from different origins should have quarantine facilities and quarantine duration for in-coming animals should be at least 14 days. | 3.5.7. Disease management issues |
| 8. Insulated buildings should be equipped with an appropriate ventilation system linked to a system for monitoring the microclimatic conditions in the building. Temperatures in such buildings should generally be maintained higher than 0°C but fully acclimatised animals will tolerate much lower temperatures. The maximum temperatures should be lower then 30°C when the relative humidity exceeds 80%. Levels of noxious gases should be kept as low as possible. The maximum ammonia concentration should be 10 ppm. | UR.3<br>Additionally:<br><br>Beef cattle confined in houses or open feedlots should be provided with structures and facilities to reduce the effects of factors contributing to thermal stress, such as excess air movement, precipitation, relative humidity and solar load. Provided that these are effective there is no need to make provision for the control of air temperature.<br><br>Change:<br><br>The maximum ammonia concentration should be < 20 ppm. | 3.4.1. Thermoregulation, and cold and heat stress |
| 9. Animals should not be kept in constant darkness or in constant light. A daily lightdark cycle should be provided sufficient to allow normal activity for the animals and to facilitate proper inspection of the animals. | No change | |
| 10. To minimise competition when ad libitum feeding is not | No change | |

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| practised, each animal should have access to the feeding trough at the same time. Simultaneous access to a feeding area for animals receiving ad libitum feeding is not necessary, but is desirable. | | |
| 11. Buildings and equipment should be checked regularly to ensure functionality and thereby avoid risk to animals. | No change | |
| 12. When animals are kept outside, they should have appropriate shelter against adverse climatic conditions such as cold, rain, wind and sun. | No change | |
| **The effects of management on cattle welfare (Section 7. of SCAHAW, 2001)** | | |
| **Mutilations (Section 7.1. of SCAHAW, 2001)** | | |
| ***Conclusions*** | | |
| 1. Castration causes severe pain and distress. According to some studies surgical castration seems to be less acceptable from a welfare point of view than Burdizzo or rubber rings. Local anaesthesia or local anaesthetic plus systemic analgesia act to reduce the pain. | UC.6<br>Additionally:<br><br>-Castration is carried out to reduce sexual activity and accelerate fattening.<br>-Pain may continue for weeks after castration.<br>-Weight loss increases as the age of castration is increased and is independent of the method used. | 3.5.1. Mutilations |
| 2. Castration, where it has to be carried out is probably best done using a combination of Burdizzo and rubber rings, as in lambs. | UC.7<br>Change:<br><br>New evidence suggests that castration by rubber ring alone is less painful than a combination of Burdizzo and rubber rings.<br><br>Additionally:<br><br>-Immunocastration has been shown to reduce aggressive and sexual behaviour of treated bulls.<br>-Surgical castration may lead to complications, such as haemorrhage, infection, severe inflammation and tetanus. | 3.5.1. Mutilations |
| 3. Spaying is likely to cause severe pain and distress and there is no indication for it. | UC.8<br>Additionally: | 3.5.1. Mutilations |

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| | Spaying causes pain, may lead to complications, such as peritonitis, and its indications can be replaced by management decisions. | |
| 4. Tail docking is likely to cause pain and interfere with the normal behaviour of the animal. | UC.9<br>Additionally:<br><br>The tail is essential for insect control. | 3.5.1. Mutilations |
| 5. Dehorning by any amputation method causes severe pain and distress. Local anaesthesia and systemic analgesia can reduce, in the short term, the pain caused by dehorning. | UC.10<br>Additionally:<br><br>Approximately 15 % of beef cattle in Europe are dehorned. | 3.5.1. Mutilations |
| 6. Disbudding of young calves may be more acceptable than dehorning from a welfare point of view and does not cause as much pain as dehorning older animals. | UC.11<br>Additionally:<br><br>-Approximately 35 % of beef cattle in Europe are disbudded.<br>-Disbudding or dehorning under sedation only (e.g. xylazine) will result in severe stress and pain. | 3.5.1. Mutilations |
| 7. Hot branding causes more pain than freeze branding. | No change | |
| | NC.2 Partial glossectomy, to prevent cross-sucking, causes severe pain and discomfort. | 3.5.1. Mutilations |
| 8. The pain and distress caused by surgical mutilations are likely to be at least as painful in young as in older animals. | UC.12<br>Change:<br><br>Young animals are as sensitive to pain as older animals but the trauma involved in mutilations is much greater in older animals. | 3.5.1. Mutilations |
| ***Recommendations*** | | |
| 1. As a general rule, mutilations should be avoided and their negative effects minimised as much as possible. | No change | |
| 2. Animals should always be provided with some form of analgesia at the time of surgical mutilations for procedures like docking, dehorning and castration (e.g. local anaesthetic), and for two days or so thereafter (e.g. a non-steroidal anti-inflammatory drug). | UR.4<br>Change:<br><br>Animals at any age should always be provided with local or regional anaesthesia at the time of surgical mutilations, as well as systemic analgesia for two days thereafter. | 3.5.1. Mutilations |
| 3. If performed, castration should be carried out in animals at as young an age as possible and ideally not in animals aged over | UR.5<br>Additionally: | 3.5.1. Mutilations |

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| six months. Effective techniques to alleviate the pain and distress caused by castration should be used. | -Rubber ring castration should only be used in animals only under the age of 2 months and the scrotum should be cut after 8-9 days of ring application.<br>-Surgical castration should only be performed by a veterinarian. | |
| 4. Spaying should not be carried out in females of any age. | No change | |
| 5. As a general rule, dehorning should not be performed. If dehorning has to be carried out, however, systemic analgesia and local anaesthesia should be provided by a veterinary surgeon. | UR.6<br>Additionally:<br><br>-The anaesthesia must be local or regional and accompanied by prolonged systemic analgesia.<br>-Disbudding under sedation of alpha-2 adrenergic receptor agonists, such as xylazine, should only be carried out in combination with a (local) anaesthetic and analgesic. | 3.5.1. Mutilations |
| 6. a) Disbudding of young calves is much more acceptable than dehorning from a welfare point of view.<br>b) The use of caustic substances for this purpose is not acceptable. | a) No change<br><br>UR.7<br>b) Change:<br><br>Cautery should be preferred over the use of caustic substances. If caustic paste is to be used care must be taken to avoid it running onto the face or being licked by other animals. | 3.5.1. Mutilations |
| 7. Tail docking is not acceptable as a method to prevent tail tip necrosis or for any other non-therapeutic purpose. Tail tip necrosis should be prevented by avoiding overcrowding, by improving bedding and by avoiding slats in the lying area. | No change | |
| 8. Hot branding should not be used. | No change | |
| | NR.2 Glossectomy to any degree should be prohibited. | 3.5.1. Mutilations |
| **Genetics (Section 7.2. of SCAHAW, 2001)** | | |
| ***Conclusions*** | | |
| 1. A large genetic variability in several traits is observed in cattle. | No change | |
| 2. Beef breeds have been selected for a high meat production. | UC.13 | 3.5.2. Genetics |

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| These breeds are often associated with a hypermuscularity which can cause leg disorders, increase calving difficulties and decrease cow longevity. | Additionally:<br><br>Genetic selection in favour of muscle growth leads to a higher proportion of fast-twitch glycolytic fibres at the expense of slow-twitch oxidative fibres. | |
| 3. Among hypermuscular animals, the homozygous carriers of myotrophin defective gene, or double muscled animals, need much more care due to their higher susceptibility to stress. A high proportion of caesareans are carried out in these animals. | No change | |
| 4. Health parameters, in particular lameness, are genetically dependent. | No change | |
| 5. Cattle from some breeds have a higher social activity than others. | No change | |
| 6. Reaction to handling is genetically dependent. | UC.14<br>Change:<br><br>Temperament of beef cattle is moderately heritable and the phenotype can be quantified using a set of well-defined animal-based measures. | 3.5.2. Genetics |
| 7. Naturally polled breeds exist. The use of naturally polled breeds avoids the need to disbud animals. | UC.15<br>Additionally:<br><br>New solutions using genetic markers are available for the welfare problem caused by dehorning/disbudding. Breeding polled cattle is a non-invasive, welfare friendly method for replacing the practice of dehorning. | 3.5.2. Genetics |
| ***Recommendations*** | | |
| 1. When producing animals for the beef herd, the selection index should include as a high priority, qualities which will improve the welfare of animals. | No change | |
| 2. Selection for high docility should be promoted. | No change | |
| 3. Selection for improved musculo-skeletal factors which can reduce lamenesses should be encouraged. Selection for high body weight or fast growth is acceptable only if welfare is not decreased. | No change | |

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| 4. Easy calving qualities should be promoted in beef breeds. | No change | |
| 5. Animals bearing mutations which lead to welfare problems should not be selected for breeding. Homozygous double muscled animals have a wide range of problems and should not be used in beef production. The use of heterozygous animals bearing the double muscling gene would still entail welfare problems in the stock of parental homozygous animals. | No change | |
| 6. The selection of naturally polled animals should be encouraged as this avoids the need for disbudding or dehorning. | UR.8<br>Additionally:<br><br>Research to develop an accurate breed-specific DNA test for the poll gene is needed. Breed societies should engage with the cattle industry to overcome certain misconceptions about breeding polled cattle. Specific polled-bull breeding programmes need to be developed by the beef breeding industry to increase the number of polled bulls available. | 3.5.2. Genetics |
| | NR.2 Research is needed to assess if the changes in proportion of muscle fibre types associated with genetic selection for increased muscularity has a negative effect on the welfare of beef cattle. | 3.5.2. Genetics |
| | NR.3 A selection programme should be implemented to genetically improve temperament in beef cattle in order to achieve about substantial welfare benefits. | 3.5.2. Genetics |
| | NR.4 Research efforts aimed at developing tools needed for implementation of marker-assisted selection to improve genetic resistance to pathogen-associated diseases should receive high priority, since genetic improvement of disease resistance will also achieve substantial, permanent and cumulative improvements in welfare of beef cattle. | 3.5.2. Genetics |
| **Feeding (Section 7.3. of SCAHAW, 2001)** | | |
| ***Conclusions*** | | |
| 1. Improper feeding can affect the welfare, including the health, of fattening cattle. | No change | |
| 2. Energy and protein supply and the provision of fibre and | No change | |

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| water are the major nutritional factors determining the growth, feed efficiency and body composition of beef cattle. In addition, the supply of minerals, trace elements and vitamins are important to ensure undisturbed growth. Nutritional requirements for beef cattle are well described in the literature. | | |
| 3. In roughage based feeding regimes, bloat can occur when the percentage of legumes in the diet is high and when cattle are not adapted to digest those legumes. | UC.16<br>Additionally:<br><br>Bloat can also occur in growing cattle fed high quantities of finely ground grains. The prevalence of feedlot bloat can be greatly reduced by incorporating at least 15 % roughage in the diet. | 3.5.3. Nutrition and feeding |
| 4. Shortages in water supply and in feed, as well as poor quality water and feed can be the cause of severe stress for the animals and result in various metabolic disorders. | No change | |
| 5. Rumen and metabolic acidosis is a severe stress for beef cattle. The occurrence of acidosis is closely related to feeding regimes that are based on a high proportion of concentrates combined with a low intake of structured crude fibre. | UC.17<br>Change:<br><br>-Beef cattle fed intensively on high grain rations (< 15 % physically effective fibre) are at a high risk of digestive disorders, especially sub-acute ruminal acidosis (SARA).<br>-Cattle that experience repeated episodes of SARA are at risk of rumen parakeratosis, liver abscesses and laminitis.<br>Measures for the control of SARA include the feeding of buffers, drugs to stimulate salivation and antibiotics (e.g. tylosin, monensin). | 3.5.3. Nutrition and feeding |
| 6. The proportion of roughage that is necessary to exclude the incidence of clinical and subclinical acidosis depends on the specific feedstuffs as well as the content and the structure of crude fibre in the diet. There are methodological difficulties in the assessment of the level of minimum requirements for beef cattle in relation to structured crude fibre. However, it seems that a minimum of 10% long fibre roughage dry matter in the diet is required to avoid pathological conditions and poor welfare. | No change | |

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| 7. Deficits in the supply of minerals and vitamin D to beef cattle undergoing rapid growth due to intensive feeding can cause skeletal lesions, especially when housing conditions are poor. | No change | |
| 8. Specific substances in the diet such as mycotoxins can lead to health problems. | UC.18<br>Additionally:<br><br>Poorly conserved silage may be a source of mycotoxins, and pathogenic bacteria such as *Listeria* and *Clostridium* spp. | 3.5.3. Nutrition and feeding |
| ***Recommendations*** | | |
| 1. The specific nutritional requirements of the animals should be met to ensure good welfare, including good health. Good quality water should be freely available. | UR.9<br>Change:<br><br>In order to meet the needs of beef cattle in relation to physiology, health and behaviour, the feed should satisfy four essential criteria:<br>-provision of adequate and balanced amounts of ME and all other essential nutrients, as required for maintenance, activity, reproduction and growth;<br>-provision of feed of a physical and chemical composition consistent with stable fermentation in the reticulo-rumen and healthy digestion in the gastro-intestinal tract; provision of feed in a form that provides oral satisfaction (e.g. rumination) and does not predispose to stereotypic behaviour;<br>-provision of feed that does no harm. | 3.5.3. Nutrition and feeding |
| 2. A sufficient daily amount of long fibre should be given to the animals to ensure normal rumen function and to fulfil the need for foraging behaviour. This is especially important where the diet is concentrate based or low fibre maize silage. A minimum of 10% of long fibre foodstuff should be provided. | UR.10<br>Change:<br><br>-Rations for finishing cattle should include at least 15 % physically effective fibre in order to reduce the risk of bloat, SARA and its sequelae.<br>-Feed supplements for the control of SARA should be restricted to those that stabilise rumen pH through natural buffering, rather than the selective manipulation of rumen microorganisms. | 3.5.3. Nutrition and feeding |
| 3. In order to prevent bloat, high clover content in the diet should be avoided and a sufficient portion of structured roughage should be offered. | No change | |

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| 4. Animals should not be underfed so that they lose weight. Particular attention should be paid to the animals kept outdoors which may have increased nutritional need for maintenance. | No change | |
| 5. The availability and quality of feed and water supplies should be checked at least daily. | No change | |
| **Grouping of animals (Section 7.4. of SCAHAW, 2001)** | | |
| ***Conclusions*** | | |
| 1. High frequencies of social disturbances are observed when the animals are mixed. | UC.19<br>Change:<br><br>-Mixing and regrouping of cattle increase the incidence of agonistic behaviours and also have disadvantages from a health perspective.<br>-Older and more aggressive animals may cause trauma and continuous and severe stress to lower ranking calves (bullers).<br>-Small and young animals are more prone to disease if kept with larger and older animals.<br>-Young heifers may be harassed and become pregnant when kept with sexually mature bulls. | 3.5.4. Grouping of animals |
| 2. Steers implanted with oestrogens have a higher social and sexual activity. | This practice is prohibited in the EU | |
| 3. Electrified grids above the animals are sometimes used for curbing the mounting activities of bulls at high stocking densities but probably cause disturbance to the animals. | UC.20<br>Change:<br><br>Solid bars or electrified grids are sometimes used for curbing the mounting activities of bulls at high stocking densities but cause disturbance to the animals. | 3.5.4. Grouping of animals |
| ***Recommendations*** | | |
| 1. Mixing of animals during the fattening period should be avoided in order to limit the risk of injuries due to increased fighting. | UR.11<br>Change:<br><br>Groups should be made up with animals of similar age, weight and sex. | 3.5.4. Grouping of animals |
| 2. Little specific information is available on maximum group size. However, it appears that the size of the group should be | No change | |

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| limited to around 40 animals. Above that level, animals may have problems in establishing a stable social structure, making fighting more likely. | | |
| | NR.5 Care should be taken to identify and remove buller animals from groups where they are subject to attacks. | 3.5.4. Grouping of animals |
| **Weaning (Section 7.5. of SCAHAW, 2001)** | | |
| ***Conclusions*** | | |
| 1. Beef cattle, both calves and cows, are stressed at weaning because of the many changes to which they are subjected. | No change | |
| 2. Preconditioning is practised to prepare the calf that has been suckling its mother to withstand the stresses associated with shipping and adapting to a feed lot environment. | No change | |
| 3. How weaning is carried out may have an impact on weight gain and health for several months after weaning. | No change | |
| 4. Early weaning demands a more careful management of the calf than late weaning. | No change | |
| | NC.3 It remains unclear whether two-stage weaning methods for calves of approximately 180 days of age, such as fenceline contact or the use of nose flaps, actually provide better welfare for the calves as compared with immediate total separation. | 3.5.5. Weaning |
| ***Recommendations*** | | |
| 1. Specific care should be given to the newly weaned suckling calves. They should be kept in groups of familiar animals to avoid fighting and cross-contamination. If some mixing is necessary, and in order to minimise disease, the environment should minimise stress and appropriate treatments should be given. Weaning should be carried out so that stress is minimal in both cows and calves. | No change | |
| 2. Routine early weaning of suckled beef calves (2-3 months) should be avoided, as this can have a negative impact on health of the calves. Weaning at 6 to 9 months is recommended. | No change | |
| 3. Calves should be encouraged to eat some solid feed at an early age and especially in the four-week period prior to weaning at 6 to 9 months of age. | No change | |

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| 4. Preconditioning should be carried out on calves before transportation to new environments | No change | |
| | NR.6 More research into the welfare benefits of two-stage versus abrupt weaning methods of calves from suckler herds should be carried out. | 3.5.5. Weaning |
| **Human-animal interaction (Section 7.6. of SCAHAW, 2001)** | | |
| ***Conclusions*** | | |
| 1. The skill and care of the stockpersons and the way in which they interact with the animals has a considerable influence on the behaviour and welfare of the animals. | UC.21<br>Additionally:<br><br>-Human contact during the first days of life appears to be most effective in terms of reducing fear of humans compared to later periods.<br>-Factors such as breed, temperament or presence of the dam may limit the effect of handling treatment.<br>-The testing of avoidance at the feeding site appears to be a promising measure of human-animal relationship in beef cattle. | 3.5.6.Human-animal interaction |
| 2. Correct handling facilities facilitate thorough examination of the animals, improve the welfare of the animals and reduce risks for the handler | No change | |
| 3. The tendency in agriculture has been to reduce contact between animals and humans, either by extensive farming or by the use automated systems. This has caused problems for welfare and individual production. | No change | |
| 4. The quality of stockmanship has large effects on the welfare of beef cattle in any housing system. A skilful stockperson can compensate for many bad effects of certain housing systems and a poor stockperson causes problems in an otherwise good system. | No change | |
| 5. Stockmen play a critical primary role in promoting the welfare, including health, of cattle in their care and provide essential early disease surveillance. | No change | |
| ***Recommendations*** | | |
| 1. Persons responsible for cattle should ensure that the welfare of the animals, including their health, is safeguarded by the use | No change | |

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| of appropriate techniques. Every person who is in charge of fattening cattle should be licensed for this occupation. Such licensing should follow proper training and certification of competence. | | |
| 2. A good relationship between the handler and the animals should be promoted in order to limit the handling stress for the animal and the risk of injury for the handler. | UR.12<br>Additionally:<br><br>Handling facilities for fattening beef cattle should be designed in such a way as to minimise the need for direct contact between handler and animal, so as to limit stress for the animal and risk of injury to the handler. | 3.5.6.Human-animal interaction |
| | NR.7 The effects of group size on the quality of human-cattle interactions should be further studied. | 3.5.6.Human-animal interaction |
| **Disease management issues (section 7.7. of SCAHAW, 2001)** | | |
| ***Conclusions*** | | |
| 1. Infectious diseases are important welfare problems. Effective healthcare therefore requires that cattle be kept in appropriate environments. Preventive measures, for example good hygiene and appropriate vaccination regimes, can help avoid infection of herds. | No change | |
| 2. Many diseases are multi-factorial. Their development may depend on the husbandry conditions of the cattle. Effective health care therefore requires that cattle are kept in environments which do not cause stress and reduced immunocompetence. | UC.22<br>Change:<br><br>Most beef cattle diseases have a multi-factorial aetiology. In addition to pathogens and animal-related conditions, other contributing factors include stocking density and environmental stressors that disturb homeostasis in the animal. | 3.5.7. Disease management issues |
| 3. Regular inspection by a competent stockperson is important in ensuring good welfare. | No change | |
| 4. Additional pens are necessary on farms in order to separate animals and to improve treatment and humane care. | No change | |

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| | NC.4 Chronic infections usually arise when animals are not detected and treated early in the course of disease. Chronic pneumonias cause very poor welfare with pain, asphyxiation and ill-thrift. | 3.5.7. Disease management issues |
| | NC.5 Preconditioning has shown to be a sound and efficient management procedure that is associated with reduced morbidity and mortality. | 3.5.7. Disease Management issues |
| ***Recommendations*** | | |
| 1. In order to minimise disease in cattle, they should be kept in environments which do not cause stress and reduced immuno-competence. | UR.13<br>Additionally:<br><br>To promote effective control of multi-factorial infectious diseases cattle should be kept in environments that minimise physiological and emotional stress. | 3.5.7. Disease Management issues |
| 2. Each animal should be inspected at least once daily. This inspection should be sufficient to detect lameness or other disease conditions. If any abnormality is detected, the animal should receive appropriate treatment as soon as possible. | No change | |
| | NR.8 The use of antimicrobials should be based on evidence from continuous monitoring of disease, including laboratory diagnosis of samples from sick and dead animals. Prophylactic use of antimicrobials should not be practised on a routine basis. | 3.5.7. Disease Management issues |
| | NR.9 Early diagnosis and treatment should be practised to prevent chronic pneumonia. | 3.5.7. Disease Management issues |
| | NR.10 Calves showing severe respiratory distress after multiple treatments should be humanely killed on the farm. | 3.5.7. Disease Management issues |

**Section 2: CALVES kept in intensive farming systems**

| **Calves** | | |
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| **EFSA 2006 Scientific Opinion** | **This Scientific Opinion** | |
| | **New conclusions and recommendations following the present evaluation** | **Relevant section** |
| **Comparison of systems and factors (Section 9. of EFSA, 2006)** | | |
| **Feeding and housing systems, weaning strategies and quality of solid and liquid feed (Section 4.1. of EFSA, 2006)** | | |
| **Feeding systems and weaning strategies (Sections 9.1.1. of EFSA, 2006)** | | |
| ***Recommendations*** | | |
| 1. a) Without a fully functional rumen, calves will be unable to utilise nutrients provided in the post-weaning dry feed diet.<br><br>b) Attention must paid to type of forage and consistent of particle size of starter grain in order to achieve a proper rumen development.<br><br>c) Calf weaning should be based on the amount of dry feed calves ingest per day, not on their age or weight, and calf starter should be made available five to 10 days after birth.<br><br>d) A calf consuming 0.7 kg of dry feed or more on three consecutive days is ready for weaning.<br><br>e) When calves are fed low levels of milk to encourage early consumption of dry food, weaning can be done abruptly. In contrast, if milk is given in large amounts, weaning may require two to three weeks of slow transition to avoid a setback in growth. | a) Change: it is a conclusion<br><br>b) No change<br><br>c) No change<br><br>d) Change: it is a conclusion<br><br>e) No change | |
| **Quality of solid and liquid feed (Section 9.1.3. of EFSA, 2006)** | | |
| ***Conclusions*** | | |

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| 1. a) The provision of solid feeds with adequate content and balance to veal calves is a prerequisite for the development of a healthy and functional rumen, the prevention of abnormal oral behaviours, and the stimulation of normal rumination activity.<br><br>b) Although some solid feeds may exacerbate problems with abomasal ulcers in milk-fed veal calves, properly balanced rations seem to moderate this effect. | UC.1<br>a) Change:<br><br>The provision of solid feed for white veal calves containing adequate amounts of functional fibre is a prerequisite for the development of a healthy and functional rumen, the prevention of abnormal oral behaviours, and the stimulation of normal rumination activity.<br><br>b) No change | 4.3.1. Feeding and housing systems, weaning strategies and quality of solid and liquid feed |
| 2. Nutritional factors are clearly involved in the etiology of abomasal ulcers in veal calves. Important elements include the consumption of large quantities of milk replacer and the interaction between a milk replacer diet and the provision of roughage. | No change | |
| 3. If vegetable proteins are not properly treated, milk replacers may cause hypersensitivity reactions in the gut, which may compromise calf welfare. | No change | |
| | NC.1 Several physiological disturbances in veal calves, including hyperglycemia, glucosuria (excretion of glucose in urine), insulin resistance, and abomasal overload caused by high feeding levels of milk replacer and limited number of meals per day can be prevented by decreasing the feeding level and increasing the feeding frequency. | 4.3.1. Feeding and housing systems, weaning strategies and quality of solid and liquid feed |
| | NC.2 High feeding levels of milk replacer in combination with a limited number of meals per day have been associated with physiological disturbances in veal calves, including hyperglycaemia, glucosuria, insulin resistance, and "ruminal drinking". Decreasing the feeding level and increasing the feeding frequency may help to alleviate these problems. | 4.3.1. Feeding and housing systems, weaning strategies and quality of solid and liquid feed |
| ***Recommendations*** | | |
| 1. It is recommended that solid feeds provided to veal calves, in addition to milk replacer, are adequately balanced in terms of | No change | |

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| the amount of fibrous material, which will promote rumination, and other components such as proteins and carbohydrates, which stimulate rumen development and support a healthy function of the digestive system. | | |
| 2. Since milk replacer formulations are frequently changing, it is recommended to carefully and consistently examine allergenic properties and other possibly detrimental effects of all milk replacers before they are used on a large scale. | No change | |
| | NR.1. The feeding frequency of milk replacer in white veal calves should be increseaded, preferably to more than three meals a day, in order to alleviate problems associated with a disturbed glucose metabolism and metabolic stress. The effect of feeding level and feeding frequency on metabolic and other health problems in veal calves requires further research. | |
| **Dietary iron and anaemia (Section 9.1.4. of EFSA, 2006)** | | |
| ***Conclusions*** | | |
| 1. If the concentration of haemoglobin in the blood of calves drops below 4.5 mmol l-1, the ability of the calf to be normally active as well as lymphocyte count and immune system function are substantially impaired, and there is reduced growth rate. Below 5.0 mmol l-1, veal calves exhibit a number of adaptations to iron deficiency, including elevated heart rate, elevated urinary noradrenaline and alterered reactivity of the HPA axis. There is a lack of data on the variability in groups of calves. Hence, when haemoblogin levels are found to be below 6.0 mmol l-1 in groups of young veal calves, it is field practice to give supplementary iron. For older calves, including those in the last four weeks before slaughter, efficient production is possible in individual calves whose haemoglobin concentration is above 4.5 mmol l-1. | Supported by further evidence | |
| 2. If the concentration of haemoglobin in blood is not checked at all, there is a high risk of anaemia that is associated with poor welfare, for all calves fed a diet with a very low iron content. Anaemia can be identified and quantified adequately if checks are carried out on veal production calves of 2-4 weeks, | No change | |

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| for example, when the calves are brought into a unit, between 12-14 weeks of fattening, and during the last four weeks before slaughter. | | |
| 3. If the concentration of haemoglobin in the blood of a group of calves during the last four weeks before slaughter is a mean of 4.5 mmol l-1, some calves may have a concentration substantially lower than the group-mean, and hence their welfare may be poor. | No change | |
| | NC.3 Clinical signs and symptoms of iron-deficiency anaemia may already occur prior to an actual decrease of blood haemoglobin levels. | 4.3.1. Feeding and housing systems, weaning strategies and quality of solid and liquid feed |
| | NC.4 In humans, the provision of iron to individuals who are infected with pathogens may be associated with serious side-effects. This may also be the case for farm animals, including veal calves. | 4.3.1. Feeding and housing systems, weaning strategies and quality of solid and liquid feed |
| ***Recommendations*** | | |
| 1. In order to avoid anaemia levels that are associated with poor welfare because normal activity is difficult or not possible and other functions are impaired, it is advisable that diets should be provided that result in blood haemoglobin concentrations of at least 6.0 mmol l-1 throughout the life of the calf. In order to avoid serious impairment of immune system function and hence poor welfare, no individual calf should have a blood haemoglobin concentration lower than 4.5 mmol l-1. In most cases this is achieved by adjusting the concentration of iron in the diet and having an adequate checking system so that the above condition is avoided. Other treatment may be needed for calves with clinical conditions | No change | |

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| | which cause anaemia but which are not related to diet. | | |
| 2. | a) Since the lowest haemoglobin concentrations in the blood of veal calves are usually reached during the last four weeks before slaughter, these blood concentrations should be checked at this time. Such controls would help to see if measures are necessary to be taken or not. A checking system using a mean level, but whose aim is to avoid the risk of a low haemoglobin concentration in any individual lower than 4.5 mmol l-1 would have to use a mean substantially higher than 4,5 mmol l-1, probably 6 mmol l-1, and an appropriate sample size.<br><br>b) In order to avoid poor welfare associated with anaemia, as explained in the Conclusions (above), measurements of average blood haemoglobin concentration are not a satisfactory means of avoiding poor welfare but the use of a minimum level of 4.5 mmol l-1 for individual calves would achieve this.<br><br>c)There is a lack of data on the haemoglobin levels and variation in groups in slaughtering calves. To gain more information as a basis for further actions and recommendations, it is advisable to perform sampling of calves at slaughter, by checking the haemoglobin level on a random basis in groups of calves. | a) No change<br><br>b) No change<br><br>UR.1<br>c) Additionally:<br><br>Other clinical and biochemical parameters, in addition to blood haemoglobin levels, should be included as indicators of anaemia in order to safeguard the welfare of veal calves restricted in their dietary iron supply. This topic requires further research. | 4.3.1. Feeding and housing systems, weaning strategies and quality of solid and liquid feed |
| | | NR.2 In the context of the production of white veal, treatment with supplemental iron should take place as much as possible at the level of the individual animal rather than the herd. | 4.3.1. Feeding and housing systems, weaning strategies and quality of solid and liquid feed |
| | | NR.3 The white veal industry should be required to provide figures for the concentration and concentration ranges of blood | 4.3.1. Feeding and housing |

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| | haemoglobin in the EU population of white veal calves, throughout the fattening period, and on the incidence of diseases. | systems, weaning strategies and quality of solid and liquid feed |
| **Space and pen design (Section 9.3. of EFSA, 2006)** | | |
| ***Conclusions*** | | |
| | NC.5 Especially at the beginning of the fattening period, veal calves housed in large groups (> 15 calves) may be more at risk for respiratory disease than animals kept either individually or in small groups (< 6 calves). | 4.3.2. General housing |
| | NC.6 A reduction of the lying space allowance from 1.25 $m^2$ to 0.75 $m^2$ per animal for calves with a live weight up to 100 kg and a reduction from 1.50 $m^2$ to 1.00 $m^2$ per animal for calves with a live weight up to 150 kg, decreased the occurrence of synchronous resting and reduced the possibility to lie in a relaxed recumbent posture. | 4.3.3. Space and pen design |
| | NC.7 Addition of an environmentally-enriched post-feeding area to an automatic milk feeding system may reduce cross-sucking in group-housed calves reared for white veal. | 4.3.3. Space and pen design |
| ***Recommendations*** | | |
| 1. Space should be enough to allow animals to fulfil their needs for social behaviour, lying and grooming. | Supported by further evidence | |
| 2. As the pen shape affects the use of space by animals, pens should be rectangular rather than square and pen space should be divided into different usable areas. | Supported by further evidence | |
| | NR.4 More research should be focused on pen design to improve calf comfort and achieve environmental enrichment. | 4.3.3. Space and pen design |
| **Flooring and bedding material (Section 9.4. of EFSA, 2006)** | | |
| ***Conclusions*** | | |
| | NC.8 At present, white and pink veal calves are almost exclusively kept on wooden slatted floors and concrete slatted floors, respectively. The available data, however, suggest that other floor types may be more comfortable and may possibly provide health benefits. There is some evidence that floor type | 4.3.4. Flooring and bedding material |

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| | may have an effect on the health of artificially reared calves, in particular with regard to the risk of diarrhoea, which was higher on farms with concrete slatted floors relative to farms with other floors. | |
| | NC.9 The prevalence of bursal swelling in the knee was significantly higher in white veal calves housed on concrete (about 17 %) than that in calves housed either on wooden slats (about 7 %) or on rubber or straw (< 1 %). The difference in average prevalence of swelling of the bursa in the knee was also significantly higher in calves housed on wooden slats than calves housed on rubber or straw. | 4.3.4. Flooring and bedding material |
| | NC.10 Provision of small amounts of straw or rubber mats for veal calves on wooden slats can result in discomfort due to dirty and wet floors, unless these floors are well managed. | 4.3.4. Flooring and bedding material |
| ***Recommendations*** | | |
| 1. As the floor type affects the resting and lying postures of calves it should be comfortable. Wet floors should be avoided due to thermal and resting problems. | Supported by further evidence | 4.3.4. Flooring and bedding material |
| | NR.5 Welfare-friendly floor types and their alternatives should be researched for intensively kept veal calves, particularly for the relationship between floor type and (veal) calf health, such as diarrhoea. | 4.3.4. Flooring and bedding material |
| **Degree of social contact (Section 9.5. of EFSA, 2006)** | | |
| ***Conclusions*** | | |
| 1. Group housing can help calves to acquire social skills. Some experience of mixing is important as calves that have been reared for a while in groups dominate calves that have always been in individual crates. | No change | |

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| 2. When calves are mixed together in the first few days of life, and then kept for some weeks in a social group, there may be poor welfare because of the following risks:<br>a) Especially when individuals are provided with inadequate access to teats and roughage in the diet, cross-sucking and other abnormal sucking behaviour may occur.<br>b) Some individuals may be unaccustomed to the food access method, for example they may have only received food via a teat, and may find it difficult to drink from a bucket.<br>c) Calves coming from different buildings, perhaps from different farms, may carry different pathogens and hence there is a risk of disease spread in all the calves that are put in the same airspace or are otherwise exposed to the pathogens. | UC.2<br>Additionally:<br><br>Group housing of calves results in better welfare for this social species, except when there is significant risk of enteric or respiratory infectious diseases. | 4.3.5. Degree of social contact |
| ***Recommendations*** | | |
| 1. Since calves are social animals, they should be kept in social groups wherever possible. These groups should be stable with no mixing or not more than one mixing. It is advisable for calves in the first two weeks of life not to be mixed with other animals. | UR.2<br>Additionally:<br><br>In order to minimise the risk of poor welfare, calves should be managed so as to minimise exposure to enteric and respiratory infection. | |
| 2. If calves from different buildings, perhaps different farms, are to be mixed in a pen or are to be put in different pens in the same airspace, quarantining animals for 3-4 weeks can reduce disease in the calves and hence prevent poor welfare. | No change | |
| 3. Although cross-sucking can sometimes be minimised by provision of teats, water and roughage, if this is not possible, mixing into groups could be delayed for three to four weeks. Calves fed by various means may require careful supervision after being put into groups in order that they learn how to feed effectively. | UR.3<br>Change:<br><br>Since calves have to be kept in groups after 8 weeks of age, supervision should be required in the period after mixing to ensure that all calves learn how to feed effectively. | |
| | NR.6. More research should be carried out to examine the optimal age and strategy for moving individually-housed calves to group housing under intensive husbandry conditions. | |
| **Temperature, ventilation and air hygiene (Section 9.6. of EFSA, 2006)** | | |
| ***Conclusions*** | | |

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| 1. Calf rearing causes significant emissions of substances such as nitrate, phosphate, heavy metals and possibly antibiotics in manure and liquid effluents. In addition, there are odours, gases, dusts, micro-organisms and endotoxins in the exhaust air from animal houses. Also in the handling of manure in storage and during application of manure and during grazing. | No change | |
| 2. These effluents can have distinct impacts on air, water, soil, biodiversity in plants, forest decay and also on animals and including humans. | No change | |
| 3. Calf houses possess a high potential for emissions of ammonia and other gases. Dust, endotoxins and micro-organisms are emitted in lower amounts than from pig or poultry production. | No change | |
| 4. Odour, bioaerosols, ammonia, nitrogen, phosphorous and heavy metals may either have a local or a regional impact. Gases such as methane and nitrous oxide contribute to global warming. | No change | |
| 5. Respiratory disorders are the second largest reason for morbidity and mortality in calf rearing. The most important causes are environmental conditions such as hygiene, management and the physical, chemical and biological factors in the environment. | UC.3<br>Change:<br><br>Aerial pollutants in confined animal houses are detrimental to respiratory health. Primary and opportunistic microbial pathogens may cause directly infectious and allergic diseases in farm animals, and chronic exposure to some types of aerial pollutants may exacerbate multi-factorial environmental diseases, especially the respiratory disease syndrome. The environmental factors include too low temperatures, high ammonia concentrations, overstocking and poor ventilation resulting in low air quality. | 4.3.6. Temperature, ventilation and air hygiene |
| 6. Ventilation plays a decisive role in reducing the incidence of respiratory disease. Temperatures below 5 ºC can compromise lung function. | See UC.4 | |
| 7. Ammonia concentrations of more than 6 ppm seem to increase respiratory infections. Relative humidity of more than 80 % bear the risk of increased heat dissipation and can help bacteria to survive in airborne state. | See UC.4 | |
| 8. Air velocities close to the animals of more than 0.5 m/s can | UC.4 | 4.3.6. |

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| significantly increase respiratory sounds in calves. | Change:<br><br>-Conclusions from 6 to 8 related to section 9.6. of EFSA, 2006, represent a misinterpretation of a statistical analysis of simple associations without taking account of cofactors.<br>-Low ammonia concentrations reflect increased air movement, which may affect respiratory disease through increased cold stress. | Temperature, ventilation and air hygiene |
| 9. Sufficient air space in confined buildings can help to reduce the concentration of airborne bacteria. | No change | |
| 10. Calf houses contain relatively high amounts of endotoxins (640 EU) (EU: Endotoxin Unit, see Scientific Report, www.efsa.eu.int) | No change | |
| 11. There is concern that antibiotic residues may contribute to the development of bacterial resistance. | No change | |
| 12. Local and regional environmental problems are enhanced by high animal densities and insufficient distances between farms and residential areas. | No change | |
| 13. The exact quantitative contribution of calf rearing to environmental pollution and its impact on water, air, soil vegetation and nearby residents is not yet well understood. | No change | |
| 14. When housing systems are compared, although dust emission levels will seldom pose problems for the health of calves, ammonia emission levels may be high enough to exacerbate calf disease, especially when calves are kept in slatted floor units. | No change | |
| ***Recommendations*** | | |
| 1. The development of low emission production systems should be encouraged including mitigation techniques, e.g. biofilters, bioscrubbers, covered manure pits and shallow manure application. In particular there is need to reduce ammonia emissions from slatted floor units or to reduce the usage of such systems. | No change | |
| 2. Adequate and efficient feeding regimes are required with minimal wastage of nitrogen and phosphorous and limited use of growth promoters and drugs. | No change | |

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| 3. There is an urgent need for cooperative research to design appropriate ventilation systems to improve health and welfare of calves kept in confined rearing conditions. | No change | |
| 4. Temperatures for young calves should range between 5 and 26 ºC. | No change | |
| 5. Ammonia concentrations should be kept as low as possible preferably not more than 6 ppm. | UR.4<br>Change:<br><br>Ventilation should be regulated to keep ammonia concentrations as low as possible without creating draughts at the calf level. | 4.3.6. Temperature, ventilation and air hygiene |
| 6. Housing and management should aim a reducing dust, bacteria and endotoxin concentrations in the animal house air. | No change | |
| 7. Minimum ventilation rates of 10 $m^3$ per 100 kg live weight should be applied. | No change | |
| **Human-animal relationships (Section 9.7. of EFSA, 2006)** | | |
| ***Recommendations*** | | |
| 1. Stockpersons should be appropriately trained so that they have sufficient skills in rearing calves. They should have a positive attitude towards animals and work with them in order to minimise stress and to maintain a high quality of health control. Rough contact (e.g. use of painful device such as an electric prod, loud noises) should be avoided and gentle contacts (e.g. talking softly, stroking, offering food) should be encouraged. This sort of contact is of particular importance for calves in groups or with their dam that tend not to approach humans readily. | No change | |
| **Dehorning and castration (Section 9.8. of EFSA, 2006)** | | |
| ***Conclusions*** | | |
| | NC.11 Calves reared for white veal are neither disbudded nor castrated. Disbudding is performed in young calves from the dairy herd destined for beef or dairy production, but the methods and pain management protocols are the same as those included in the beef cattle Chapter of this Opinion. | 4.3.8. Dehorning and castration |
| ***Recommendations*** | | |
| a) If cattle are to be dehorned, it is recommend to disbud young | For recommendations dealing with disbudding in calves, the reader | 4.3.8. |

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| cattle rather than to dehorn older ones. Disbudding by cautery is recommended over other methods.<br><br>b) Local anaesthesia (e.g. 5-6 mL lidocaine or lignocaine 2% around the corneal nerve) and analgesia with an NSAID (e.g. 5 mL Flunixin Meglumine or 3- 3.75 mg ketoprofen 10% / kg body weight) should be given 15-20 min before disbudding. | should refer to the mutilation section in the beef cattle chapter of this opinion (section 3.5.1.). | Dehorning and castration |
| 2.If cattle are to be castrated, it is recommended to castrate calves as early as possible (no later than 1.5 mo and preferably at 1 wk of age), to use the Burdizzo method, and to provide appropriate anaesthesia and analgesia (e.g. 3 mL Lignocaine 2% in each testicle through the distal pole and 3 mg Ketoprofen 10% / kg body weight injected intravenously both 20 min before castration). | See Section 1 (beef cattle) of this table | |
| **Calf diseases and use of antibiotics (Section 10. of EFSA, 2006)** | | |
| ***Conclusions*** | | |
| 1. Prevention of typical calf diseases in the first 6 months of life such as diarrhoea and enzootic bronchopneumonia requires a systematic approach by improving management and housing conditions, specifically the preparation of the cow, hygiene of the calving environment, including dry clean bedding and high air quality, immediate supply with maternal antibodies, no mixing with older animals and careful attention and a rapid response to any sign indicating disease. | UC.5<br>Change:<br><br>Ensuring good welfare in calves requires good management, and an environment that fulfils the needs of the animals, including the need to avoid disease. Prevention of typical calf diseases in the first 6 months of life, such as diarrhoea and bovine respiratory syndrome, requires a systematic approach by improving management and housing conditions, specifically the preparation of the cow, hygiene of the calving environment, including dry, clean bedding and high air quality, immediate supply with maternal antibodies, putting calves from different sources in different air-spaces, no mixing with older animals and careful attention with a rapid response to any sign indicating disease. | 4.3.11 Control and management of diseases in calves |
| | NC.12 Identifying sick animals in the early stages of disease is a crucial element for therapeutic success. Environmental factors predisposing to respiratory disease are lack of ventilation, high animal density, extreme temperatures and high relative humidity. | 4.3.11 Control and management of diseases in calves |

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| | NC.13 Calves that do not get good quality colostrum after birth are more susceptible to respiratory disease at the feedlot. | 4.3.11 Control and management of diseases in calves |
| | NC.14 Non-perforating abomasal lesions affect more than half the population of veal calves. There are less of these lesions in veal calves kept in welfare-friendly installations. | 4.3.11 Control and management of diseases in calves |
| | NC.15 Infections may occur in the umbilical cord of newborn calves, leading to bacteraemia and infection of the joints, meninges and internal organs. | 4.3.11 Control and management of diseases in calves |
| | NC.16 The average weight of calves upon arrival at the veal farm may be a risk factor for respiratory disease during the early stages of the fattening period. Light-weight-calves may be more at risk than heavier ones. | 4.3.11 Control and management of diseases in calves |
| ***Recommendations*** | | |
| | NR.7 For the major enteric and respiratory infections, supportive treatments including oral or parenteral rehydration and systemic analgesia (NSAID) should be provided. | 4.3.11 Control and management of diseases in calves |
| | NR.8 Calves from dairy farms should get an adequate quantity of colostrum at the most appropriate time. | 4.3.11 Control and management of diseases in calves |
| | NR.9 After receiving adequate colostrum and separation from their dams, artificially-reared calves should be housed in group pens that permit social contact when there is a low risk of enteric and respiratory disease. When the disease risk is high it may be | 4.3.11 Control and management of diseases in |

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| | necessary to isolate calves from contagion or short-range airborne infection until early weaning at 4-6 weeks or entry into a unit rearing calves for white veal. However, there should be no compensation for bad management of calves, such as the mixing of groups of calves from different sources, by individual housing. | calves |
| | NR.10 An on-farm humane killing (euthanasia) programme is a requirement for the welfare of severely distressed, injured, or moribund calves. This programme should be created by a veterinarian and include teaching of stockpersons to recognise calves that are candidates for euthanasia and appointment, as well as training of specific personnel to perform it competently. | 4.3.11 Control and management of diseases in calves |
| | NR.11 Frequent and competent observations of groups and individuals, including faecal scoring and early treatment and isolation of sick animals, are necessary to control diseases in calves. | 4.3.11 Control and management of diseases in calves |
| | NR.12 Navel disinfection or ligature should be performed in calves born in pens (dairy calves), when needed for hygiene reasons. | 4.3.11 Control and management of diseases in calves |
| | NR.13 The condition and immunocompetence of calves should be improved upon arrival at intensive fattening units, for example by taking heavier-weight calves. More research is required into effective strategies to enhance the condition, immunocompetence and "robustness" of calves in general upon arrival at the fattening unit. | 4.3.11 Control and management of diseases in calves |

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## APPENDICES

### A. APPENDIX 1: LIST OF UPDATED AND NEW CONCLUSIONS WITH RELEVANT ASSOCIATED HAZARD OR HAZARDS AND WELFARE OUTCOMES, BASED ON EXPERT OPINION, WITH REGARD TO WELFARE CONSEQUENCES.

Table listing updated and new conclusions regarding the welfare of beef cattle and intensively-reared calves, where relevant to risk assessment.

Conclusions of the two different Chapters of this Opinion (Chapter 3. BEEF CATTLE; Chapter 4. CALVES) have been kept separately in the relevant different sections of the table.

The first column lists updated and new conclusions, numbered as reported in the Conclusions and Recommendations section of this Opinion.

The second column identifies the hazard or hazards linked to each conclusion with regard to welfare consequences.

The third column identifies the relevant welfare outcome.

The forth column identifies the relevant section in the text of this Opinion.

**Section 1: BEEF CATTLE**

| This Scientific Opinion | | | |
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| **Updated and new conclusions following the present evaluation** | **Hazard involved** | **Welfare outcome** | **Relevant section** |
| UC.1<br>Very young animals feel pain and show signs of distress, and may feel more pain than adults.<br><br>Additionally:<br>The amount of tissue affected by mutilations is usually greater in older animals, resulting in a more extensive area of pain and a more prolonged recovery. | No pain management | Pain | 3.5.1. Mutilations |
| UC.2<br>Rumination may account for a substantial part of cattle activity. Rumination is under voluntary control and when animals are disturbed they cease to ruminate.<br><br>Additionally:<br>Rumination time is primarily determined by the quantity of long fibre in the diet and, when diets are lacking in long fibres, normal rumination and salivation are greatly reduced and can lead to digestive disorders. | High starch/fibre ratio in diet | Subacute ruminal acidosis | 3.5.3. Nutrition and feeding |
| UC.3<br>-Beef cattle can tolerate and adapt to a wide range of air temperatures.<br>-Metabolic heat production increases with increasing feed intake. Thus animals on the highest rations are least sensitive to cold and most sensitive to heat. Cold stress can be reduced by provision of | -THI > 78<br>-Without adequate ventilation<br>-Open feedlot (without shade)<br>-Ambient T° < -10 °C<br>-Chronic cold/undernutrition | - Heat stress<br>- Cold stress<br>- Respiratory disease | 3.4.1. Thermoregulation, and cold and heat stress |

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| appropriate shelter and a dry lying area. | | | |
| UC.4<br>Adequate ventilation is crucial for cattle kept indoors especially in hot weather or when density is high. Adequate ventilation can be achieved either by forced ventilation or well designed natural ventilation systems. | -THI > 78<br>-Without adequate ventilation<br>-Air quality, Ammonia concentration > 20 ppm | - Heat stress<br>- Respiratory disease | 3.4.1. Thermoregulation , and cold and heat stress |
| UC.5<br>Animals kept on slatted floors have a higher incidence of injuries and abnormal movements when standing up and lying down than animals on straw or sloped straw-bedded areas. Partial rubberisation or rubber mats on concrete floors, especially for lying areas, reduces the prevalence of lesions to claws and joints. | Concrete floors | -Lameness<br>-Abnormal behaviour/aggression | 3.4.4. Type of floor and bedding material |
| UC.6<br>Castration causes severe pain and distress. According to some studies surgical castration seems to be less acceptable from a welfare point of view than Burdizzo or rubber rings. Local anaesthesia or local anaesthetic plus systemic analgesia act to reduce the pain.<br><br>Additionally:<br>-Castration is carried out to reduce sexual activity and accelerate fattening.<br>-Pain may continue for weeks after castration.<br>-Weight loss increases as the age of castration is increased and is independent of the method used. | -Castration with no pain management<br>-Castration with local anaesthesia | Pain | 3.5.1. Mutilations |
| UC.7<br>New evidence suggests that castration by rubber ring alone is less painful than a combination of Burdizzo and rubber rings.<br><br>Additionally: | -Clamp castration | Pain | 3.5.1. Mutilations |

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| -Immunocastration has been shown to reduce aggressive and sexual behaviour of treated bulls.<br>-Surgical castration may lead to complications, such as haemorrhage, infection, severe inflammation and tetanus. | -Castration > 2 months<br><br>-Surgical castration | | |
| UC.8<br>Spaying is likely to cause severe pain and distress and there is no indication for it.<br><br>Additionally:<br>Spaying causes pain, may lead to complications, such as peritonitis, and its indications can be replaced by management decisions. | Surgical spaying | Pain and disease | 3.5.1. Mutilations |
| UC.9<br>Tail docking is likely to cause pain and interfere with the normal behaviour of the animal.<br><br>Additionally:<br>The tail is essential for insect control. | Tail tip docking | Pain | 3.5.1. Mutilations |
| UC.10<br>Dehorning by any amputation method causes severe pain and distress. Local anaesthesia and systemic analgesia can reduce, in the short term, the pain caused by dehorning.<br><br>Additionally:<br>Approximately 15 % of beef cattle in Europe are dehorned. | -Dehorning with no pain management<br>-Dehorning with local anaesthesia | Pain | 3.5.1. Mutilations |
| UC.11<br>Disbudding of young calves may be more acceptable than dehorning from a welfare point of view and does not cause as much pain as dehorning older animals.<br><br>Additionally:<br>-Approximately 35 % of beef cattle in Europe are | -Dehorning/disbudding with no pain management<br>-Dehorning/disbudding with local anaesthesia | Pain | 3.5.1. Mutilations |

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| disbudded.<br>-Disbudding or dehorning under sedation only (e.g. xylazine) will result in severe stress and pain. | | | |
| NC.2<br>Partial glossectomy, to prevent cross-sucking, causes severe pain and discomfort. | Partial glossectomy | Pain and behavioural deprivation | 3.5.1. Mutilations |
| UC.12<br>Young animals are as sensitive to pain as older animals but the trauma involved in mutilations is much greater in older animals. | Mutilations > 2 months | Pain | 3.5.1. Mutilations |
| UC.13<br>Beef breeds have been selected for a high meat production. These breeds are often associated with a hypermuscularity which can cause leg disorders, increase calving difficulties and decrease cow longevity.<br><br>Additionally:<br>Genetic selection in favour of muscle growth leads to a higher proportion of fast-twitch glycolytic fibres at the expense of slow-twitch oxidative fibres. | Hyper muscularity | Leg problems, respiratory disease | 3.5.2. Genetics |
| UC.14<br>Temperament of beef cattle is moderately heritable and the phenotype can be quantified using a set of well-defined animal-based measures. | Aggression/mounting animals | Injuries | 3.5.2. Genetics |
| UC.15<br>Naturally polled breeds exist. The use of naturally polled breeds avoids the need to disbud animals.<br><br>Additionally:<br>New solutions using genetic markers are available for the welfare problem caused by dehorning/disbudding. Breeding polled cattle is a non-invasive, welfare friendly method for replacing the practice of | Disbudding and dehorning | Pain | 3.5.2. Genetics |

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| dehorning. | | | |
| UC.16<br>In roughage based feeding regimes, bloat can occur when the percentage of legumes in the diet is high and when cattle are not adapted to digest those legumes.<br><br>Additionally:<br>Bloat can also occur in growing cattle fed high quantities of finely ground grains. The prevalence of feedlot bloat can be greatly reduced by incorporating at least 15 % roughage in the diet. | -Intensive concentrates<br>-High starch/fibre ratio in diet | -Heat stress<br>-Subacute ruminal acidosis<br>-Bloat<br>-Laminitis<br>-Para- and hyperkeratosis<br>-Liver abscess<br>-Skeletal disorders<br>-Tongue rolling<br>-Urine drinking | 3.5.3. Nutrition and feeding |
| UC.17<br>-Beef cattle fed intensively on high grain rations (< 15 % physically effective fibre) are at a high risk of digestive disorders, especially sub-acute ruminal acidosis (SARA).<br>-Cattle that experience repeated episodes of SARA are at risk of rumen parakeratosis, liver abscesses and laminitis.<br>Measures for the control of SARA include the feeding of buffers, drugs to stimulate salivation and antibiotics (e.g. tylosin, monensin). | -Intensive concentrates<br>-High starch/fibre ratio in diet | -Heat stress<br>-Subacute ruminal acidosis<br>-Bloat<br>-Laminitis<br>-Para- and hyperkeratosis<br>-Liver abscess<br>-Skeletal disorders<br>-Tongue rolling<br>-Urine drinking | 3.5.3. Nutrition and feeding |
| UC.18<br>Specific substances in the diet such as mycotoxins can lead to health problems.<br><br>Additionally:<br>Poorly conserved silage may be a source of mycotoxins, and pathogenic bacteria such as *Listeria* and *Clostridium* spp. | Moulds + bacteria | Toxaemia | 3.5.3. Nutrition and feeding |
| UC.19<br>-Mixing and regrouping of cattle increase the incidence of agonistic behaviours and also have disadvantages from a health perspective. | -Co-mingling in feedlot<br>-Mixing during fattening | Respiratory disease<br>Stress and fear | 3.5.4. Grouping of animals |

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| -Older and more aggressive animals may cause trauma and continuous and severe stress to lower ranking calves (bullers).<br>-Small and young animals are more prone to disease if kept with larger and older animals.<br>-Young heifers may be harassed and become pregnant when kept with sexually mature bulls. | | | |
| UC.20<br>Solid bars or electrified grids are sometimes used for curbing the mounting activities of bulls at high stocking densities but cause disturbance to the animals. | Use of bars/grids that prevent from mounting | Frustration | 3.5.4. Grouping of animals |
| NC.3<br>It remains unclear whether two-stage weaning methods for calves of approximately 180 days of age, such as fenceline contact or the use of nose flaps, actually provide better welfare for the calves as compared with immediate total separation. | Keeping newly weaned beef calves in sight of mothers | Stress and frustration | 3.5.5. Weaning |
| UC.21<br>The skill and care of the stockpersons and the way in which they interact with the animals has a considerable influence on the behaviour and welfare of the animals.<br><br>Additionally:<br>-Human contact during the first days of life appears to be most effective in terms of reducing fear of humans compared to later periods.<br>-Factors such as breed, temperament or presence of the dam may limit the effect of handling treatment.<br>-The testing of avoidance at the feeding site appears to be a promising measure of human-animal relationship in beef cattle. | Interaction with humans | Fear and stress | 3.5.6.Human-animal interaction |

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| UC.22<br>Most beef cattle diseases have a multi-factorial aetiology. In addition to pathogens and animal-related conditions, other contributing factors include stocking density and environmental stressors that disturb homeostasis in the animal. | -No vaccination against respiratory virus<br>-Vaccination only at entering feedlot<br>-Delay in BRD diagnosis<br>-Prior transport<br>-Failure to treat or cull<br>-No planned herd health programme | -Respiratory diseases<br>-Chronic pneumonia-ill thrift<br>-Disease | 3.5.7. Disease management issues |
| NC.4<br>Chronic infections usually arise when animals are not detected and treated early in the course of disease. Chronic pneumonias cause very poor welfare with pain, asphyxiation and ill-thrift. | -Delay in BRD diagnosis<br>-Failure to treat or cull | -Respiratory diseases<br>-Chronic pneumonia-ill thrift | 3.5.7. Disease management issues |
| NC.5<br>Preconditioning has shown to be a sound and efficient management procedure that is associated with reduced morbidity and mortality. | -No vaccination against respiratory virus<br>-Vaccination only at entering feedlot<br>-No planned herd health programme | -Respiratory disease<br>-Disease | 3.5.7. Disease management issues |

**Section 2: CALVES kept in intensive farming systems**

| This Scientific Opinion | | | |
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| **Updated and new conclusions following the present evaluation** | **Hazard involved** | **Welfare outcome** | **Relevant section** |
| UC.1<br>a)<br>The provision of solid feed for white veal calves containing adequate amounts of functional fibres is a prerequisite for the development of a healthy and functional rumen, the prevention of abnormal oral behaviours, and the stimulation of normal rumination activity.<br><br>b) Although some solid feeds may exacerbate problems with abomasal ulcers in milk-fed veal calves, properly balanced rations seem to moderate this effect. | -Restricted solid feed supply next to milk replacer during fattening<br>-Unbalanced solid feed next to milk replacer during fattening | -Health problems<br>-Abnormal oral behaviour<br>-Digestive system disorders | 4.3.1.<br>Feeding and housing systems, weaning strategies and quality of solid and liquid feed |
| NC.1<br>Several physiological disturbances in veal calves, including hyperglycemia, glucosuria (excretion of glucose in urine), insulin resistance, and abomasal overload caused by high feeding levels of milk replacer and limited number of meals per day can be prevented by decreasing the feeding level and increasing the feeding frequency. | Low feeding frequency milk replacer during fattening | Disturbed glucose metabolism | 4.3.1. Feeding and housing systems, weaning strategies and quality of solid and liquid feed |
| NC.2<br>High feeding levels of milk replacer in combination with a limited number of meals per day have been associated with physiological disturbances in veal calves, including hyperglycaemia, glucosuria, insulin resistance, and “ruminal drinking”. Decreasing the feeding level and increasing the feeding frequency may help to alleviate these problems. | -Low feeding frequency milk replacer during fattening<br>-High levels of milk replacer during fattening | -Disturbed glucose metabolism<br>-Diarrhoea<br>-“Ruminal” drinking | 4.3.1. Feeding and housing systems, weaning strategies and quality of solid and liquid feed |

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| NC.3<br>Clinical signs and symptoms of iron-deficiency anaemia may already occur prior to an actual decrease of blood haemoglobin levels. | Restricted dietary iron supply during fattening | -Clinical signs of anaemia<br>-Hb < 4.5 mmol/l | 4.3.1. Feeding and housing systems, weaning strategies and quality of solid and liquid feed |
| NC.4<br>In humans, the provision of iron to individuals who are infected with pathogens may be associated with serious side-effects. This may also be the case for farm animals, including veal calves. | -General iron treatment young calves<br>-Inaccurate monitoring of iron status<br>- haemoglobin | -Infection and disease, iron overload<br>-Clinical signs of anaemia<br>-Hb < 4.5 mmol/l | 4.3.1. Feeding and housing systems, weaning strategies and quality of solid and liquid feed |
| NC.5<br>Especially at the beginning of the fattening period, veal calves housed in large groups (> 15 calves) may be more at risk for respiratory disease than animals kept either individually or in small groups (< 6 calves). | Group size > 15 animals per group | Respiratory disease | 4.3.2. General housing |
| NC.6<br>A reduction of the lying space allowance from 1.25 $m^2$ to 0.75 $m^2$ per animal for calves with a live weight up to 100 kg and a reduction from 1.50 $m^2$ to 1.00 $m^2$ per animal for calves with a live weight up to 150 kg, decreased the occurrence of synchronous resting and reduced the possibility to lie in a relaxed recumbent posture. | Space allowance < 1.5 $m^2$/animal | Disturbed resting behaviour | 4.3.3. Space and pen design |
| NC.7<br>Addition of an environmentally-enriched post-feeding area to an automatic milk feeding system may reduce cross-sucking in group-housed calves reared for white veal. | -Feeding places solid feed lower than calves per pen<br>-> 4 calves per feeder or feeding place | Disturbed feeding behaviour | 4.3.3. Space and pen design |
| NC.8<br>At present, white and pink veal calves are almost exclusively kept on wooden slatted floors and concrete slatted floors, respectively. The available data, however, suggest that other floor types may possibly be more comfortable and may possible provide health benefits. There is some evidence that floor type may have an effect on the health of artificially reared calves, in particular with regard to the risk of diarrhoea, which was higher on farms with concrete | Slatted flooring (concrete) | -Discomfort<br>-Injury | 4.3.4. Flooring and bedding material |

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| slatted floors relative to farms with other floors. | | | |
| NC.9<br>The prevalence of bursal swelling in the knee was significantly higher in white veal calves housed on concrete (about 17 %) than that in calves housed either on wooden slats (about 7 %) or on rubber or straw (< 1 %). The difference in average prevalence of swelling of the bursa in the knee was also significantly higher in calves housed on wooden slats than calves housed on rubber or straw. | Slatted flooring (concrete) | -Discomfort<br>-Injury | 4.3.4. Flooring and bedding material |
| NC.10<br>Provision of small amounts of straw or rubber mats for veal calves on wooden slats can result in discomfort due to dirty and wet floors, unless these floors are well managed. | Slatted flooring (concrete with rubber surface) | -Discomfort<br>-Injury | 4.3.4. Flooring and bedding material |
| UC.2<br>When calves are mixed together in the first few days of life, and then kept for some weeks in a social group, there may be poor welfare because of the following risks:<br>a) Especially when individuals are provided with inadequate access to teats and roughage in the diet, cross-sucking and other abnormal sucking behaviour may occur.<br>b) Some individuals may be unaccustomed to the food access method, for example they may have only received food via a teat, and may find it difficult to drink from a bucket.<br>c) Calves coming from different buildings, perhaps from different farms, may carry different pathogens and hence there is a risk of disease spread in all the calves that are put in the same airspace or are otherwise exposed to the pathogens.<br><br>Additionally:<br>Group housing of calves results in better welfare for this social species, except when there is significant risk of enteric or respiratory infectious diseases. | Early group housing | Respiratory disease and neonatal diarrhoea | 4.3.5. Degree of social contact |
| UC.3 | -Air volume per animal < 10 $m^3$ | Respiratory disease | 4.3.6. Temperature, |

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| Aerial pollutants in confined animal houses are detrimental to respiratory health. Primary and opportunistic microbial pathogens may cause directly infectious and allergic diseases in farm animals, and chronic exposure to some types of aerial pollutants may exacerbate multi-factorial environmental diseases, especially the respiratory disease syndrome. The environmental factors include too low temperatures, high ammonia concentrations, overstocking and poor ventilation resulting in low air quality. | -Air quality, Ammonia > 20 ppm | | ventilation and air hygiene |
| UC.4<br>Low ammonia concentrations reflect increased air movement, which may affect respiratory disease through increased cold stress. | -Air volume<br>-Air quality | -Respiratory disease | 4.3.6. Temperature, ventilation and air hygiene |
| NC.11<br>Calves reared for white veal are neither disbudded nor castrated. Disbudding is performed in young calves from the dairy herd destined for beef or dairy production, but the methods and pain management protocols are the same as those included in the beef cattle Chapter of this Opinion. | - Castration with no pain management<br>- Castration with local anaesthesia<br>- Disbudding with no pain management<br>- Disbudding with local anaesthesia | Pain<br>(see Table 13 on the beef cattle risk assessment) | 4.3.8. Dehorning and castration |
| UC.5<br>Ensuring good welfare in calves requires good management, and an environment that fulfils the needs of the animals, including the need to avoid disease. Prevention of typical calf diseases in the first 6 months of life, such as diarrhoea and bovine respiratory syndrome, requires a systematic approach by improving management and housing conditions, specifically the preparation of the cow, hygiene of the calving environment, including dry, clean bedding and high air quality, immediate supply with maternal antibodies, putting calves from different sources in different air-spaces, no mixing with older animals and careful attention with a rapid response to any sign indicating disease. | -Air volume per animal < 10 $m^3$<br>-Air quality, Ammonia > 20 ppm<br>-Early group housing | -Respiratory disease<br>-Respiratory disease and neonatal diarrhoea | 4.3.11 Control and management of diseases in calves |
| NC.12<br>Identifying sick animals in the early stages of disease is a crucial element for therapeutic success. Environmental factors predisposing to respiratory disease are lack of ventilation, high animal density, extreme temperatures and high relative humidity. | -Poor management of severely sick calves<br>-No routine inspection of young animals | -Pain, ulcerations, dehydration, eye lesions<br>-Disease, dehydration | 4.3.11 Control and management of diseases in calves |
| NC.13 | -Inadequate colostrum | Health problems | 4.3.11 Control and |

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| Calves that do not get good quality colostrum after birth are more susceptible to respiratory disease at the feedlot. | -Contaminated colostrum | | management of diseases in calves |
| NC.14<br>Non-perforating abomasal lesions affect more than half the population of veal calves. There are less of these lesions in veal calves kept in welfare-friendly installations. | -Low feeding frequency milk replacer during fattening<br>-High levels of milk replacer during fattening | -Disturbed glucose metabolism<br>-Diarrhoea<br>-“Ruminal” drinking | 4.3.11 Control and management of diseases in calves |
| NC.15<br>Infections may occur in the umbilical cord of newborn calves, leading to bacteraemia and infection of the joints, meninges and internal organs. | No umbilical disinfection | Omphalitis, septicaemia, polyarthritis | 4.3.11 Control and management of diseases in calves |
| NC.16<br>The average weight of calves upon arrival at the veal farm may be a risk factor for respiratory disease during the early stages of the fattening period. Light-weight-calves may be more at risk than heavier ones. | Light weight on arrival, < 45 Kg | Disease | 4.3.11 Control and management of diseases in calves |

## B. APPENDIX 2: RISK ASSESSMENT METHODOLOGY

### Introduction

Animal welfare problems are generally the consequence of animal environment changes resulting from animal management factors or production factors. EFSA recently published the Guidance on Risk Assessment for Animal Welfare (EFSA, 2012) and this assessment follows the methodology recommended in that document.

This methodology was an adaptation of that in the Terrestrial Animal Health Code (OIE, 2011).

The animal welfare risk was defined as a function of the probability of negative welfare consequences and the magnitude of those consequences, following exposure to a particular factor or exposure scenario, in a given population.

Many management practices (e.g. vaccination) are, of course, designed to improve health and welfare. Risk factors with regard to theses practices are therefore defined by their absence (e.g. "No dam vaccination against diarrhoea causing agents").

Risk assessment has three elements: exposure assessment, consequence characterisation and risk characterisation. Exposure assessment should provide a qualitative or quantitative evaluation of the strength, duration, frequency and patterns of exposure for the factors relevant to the exposure scenario(s) developed during the problem formulation.

Consequence characterisation involves assessing the magnitude (intensity and duration) of the negative and positive welfare consequences and the probability of their occurrence at the individual level. Risk characterisation is the final step of risk assessment and is the qualitative or quantitative estimation of the probability of occurrence and magnitude of negative and positive welfare effects (known or potential) in a given population.

A structured expert elicitation method was used to score the magnitude of the effects and their duration and the exposure and the probability of occurrence at the individual level.

In a first scoring round, individual experts were asked to score each of the parameters for each population, based on current scientific knowledge and published data. In a second round of classification, the experts were asked to reconsider their scores individually knowing the scores provided by other experts but the identity of the experts was kept anonymous. In a final scoring round, those factors for which the scores were not consensual were discussed among the experts in order to clarify the factor formulation, and a consensual score was attributed to the factor.

### Factor identification

This includes identification of beneficial factors whose absence is regarded as a hazard to good welfare.

The aim of this step was to identify causes or factors that affect the animal's needs and that have a potential to change the animal's welfare (negative or positive changes).

In this step, the scientific evidence of association between the exposure to a given production factor (hazard) and the consequent impact on animal welfare were reviewed.

Production factors could have direct effects on the animal or indirect effects that change the animal's environment in a way that affects the abilities to fulfil its basic needs, which lead to an effect on the animal's welfare.

### Consequence characterisation

The objectives of this step were:

- to examine and describe the consequences of an exposure to one or several hazards in terms of the magnitude of the adverse effect,
- to assess the relationship between the level of the hazard in terms of intensity, and duration and the probability and magnitude of the adverse effect.

If the hazard is the absence of a beneficial factor, that factor was also characterised.

The intensity of the adverse effects was scored according to scientific evidence of the level of physiological and behavioural responses resulting from the exposure to the factor. This is the unrestricted intensity of the adverse effect and is not dependent on the duration of that effect. The intensity score ranged from low to high. See Table 8 for the severity characterisation scores.

**Table 8:** Adverse welfare effect intensity scores.

| Intensity of the adverse effect | Descriptive definition |
|---|---|
| **High** | Involving explicit pain, malaise, frustration, fear or anxiety<br>Strong stress reaction, dramatic change in motor behaviour, vocalisation may occur.<br>Death occurs either immediately or after some time |
| **Medium** | Some pain, malaise, frustration, fear or anxiety<br>Stress reaction, some change in motor behaviour, occasional vocalisation may occur |
| **Low** | Minor pain, malaise, frustration, fear or anxiety<br>Physiological effects may be recorded as well as moderate behavioural changes |

The duration of the effect was scored depending on the expected duration of the adverse effect on welfare at a given factor level (see Table 9).

**Table 9:** Adverse welfare effect duration scores.

| Duration of the adverse effect | Descriptive definition |
|---|---|
| **Long** | Lasts throughout the majority of the remaining expected life of the animal |
| **Medium** | Lasts for a period that ranges from 1 day to weeks |
| **Short** | Lasts less than 1 day |

The magnitude of the adverse welfare effect was classified on a qualitative score with 5 levels that ranged from very low to very high (see Table 10). This classification was based on a matrix that integrated both the intensity and duration of the adverse effect. This qualitative approach was used as a practical method to avoid strong assumptions about the linearity of the duration of the effect on the magnitude.

**Table 10:** Magnitude classification matrix.

| | | Intensity | | |
|---|---|---|---|---|
| | | **High** | **Medium** | **Low** |
| **Duration** | **Long** | Very High | High | Medium |
| | **Medium** | High | Medium | Low |
| | **Short** | Medium | Low | Very low |

The probability of an animal experiencing the adverse effect with the magnitude that was specified, given exposure to the hazard, is defined in the exposure assessment. In epidemiological terms, this is the population attributable risk to this hazard, defined by the proportional reduction on individuals with the adverse effect that would occur, if the exposure to the hazard would be reduced to zero assuming that the exposure to all the other hazards is the same (*ceteris paribus*). Quantification was carried out by using the minimum, most likely and maximum values (%) that expressed the uncertainty of the estimates. This value was later modelled as a BetaPERT distribution. Since that information may not always be available or there are studies with different conclusions for the estimation of the probability, a qualitative score for this uncertainty was also given. See Table 11 for the criteria used.

**Exposure assessment**

This is the quantitative evaluation of the magnitude and probability of an exposure to one or several hazards during the considered period of its or their life.

Exposure assessment is the assessment of the probability of each level of exposure in a defined target population. In different production systems, for the same target population significant variations of the exposure can be observed, therefore, if this is the case for a particular hazard, a new line was added to the list with the same hazard but with the indication of the hazard specification on the production system being considered.

The uncertainty in this assessment was expressed as the minimum, maximum and most likely parameters of a BetaPERT distribution. Since that information may not always be available or there are studies with different results for the estimation of the exposure, a qualitative score for this uncertainty was also given. See Table 11 for the criteria.

**Risk Characterisation**

The risk was characterised by presenting both the magnitude of the adverse effect resulting from the exposure to a factor and the probability of occurrence of that adverse effect. The probability of occurrence of the adverse effect was calculated as a function of the probability of exposure (Pe) to the factor and the probability of an animal experiencing an adverse welfare consequence (Pc) given exposure to the factor, or scenario of exposure.

Probability of occurrence = $P_c$ (probability of adverse consequence given a scenario of exposure) x $P_e$ (probability of the considered scenario of exposure)

The results were presented in this way to allow risk managers and other stakeholders to identify the factors that, when present, will have a consequence with a high magnitude on the welfare of animals and their probability of occurrence. The combination of both components of the risk on a single estimate would underestimate those factors that have a high adverse welfare effect but that have a low probability of occurrence because of a very low level of exposure (e.g. Glossectomy). Some of these are avoidable factors and have minimal impact on animal production but when used they may cause adverse effects with a very high impact on animal welfare.

The analysis also addressed the quantitative and qualitative uncertainty. Uncertainty factor analysis identifies new research studies that are needed in order to reduce the uncertainty of the estimate to a level that allows the management to make decisions with enough confidence. The probability of occurrence and 90 % credibility interval values were calculated after running a Monte-Carlo simulation model in the Modelrisk (Vosesoftware, Gent, Belgium) add-in for excel. The model was run for 20,000 iterations.

The qualitative assessment of the uncertainty was classified accordingly the classification matrix in Table 12.

**Table 11:** Qualitative uncertainty scores for probability and exposure.

| | |
|---|---|
| **Low** | Solid and complete data available; strong evidence provided in multiple references; authors report similar conclusions. |
| **Medium** | Some but no complete data available; evidence provided in a small number of references; authors' conclusions vary from one to other.<br>Solid and complete data available from other species which can be extrapolated to the species considered. |
| **High** | Scarce or no data available; rather evidence provided in unpublished reports, based on observations or personal communications; authors' conclusions vary considerably between them |

**Table 12:** Uncertainty classification matrix.

| Probability uncertainty \ Exposure uncertainty | **High** | **Medium** | **Low** |
|---|---|---|---|
| **High** | High | High | High |
| **Medium** | High | Medium | Medium |
| **Low** | High | Medium | Low |

## Results

Risk assessment results for beef cattle and calves from intensive farming are reported in the following Table 13 and Table 14, respectively.

**Table 13:** Beef cattle risk assessment: results.

| TARGET POPULATION: Beef cattle | | | | | Risk Assessment | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Section | Sub-section | Hazard identification | | | Consequence characterisation | | | | | | Exposure assessment | | | | Risk characterisation | | | | |
| | | Welfare outcome | Hazard description | Hazard specification | Magnitude | | Probability of welfare consequence given exposure to the factor | | | Uncertainty | Probability of exposure | | | Uncertainty | Magnitude | Probability of the event | | | Uncertainty |
| | | | | | Intensity | Duration | min | ML | max | | min | ML | max | | | ML | CI5% | CI95% | |
| **Housing** | | | | | | | | | | | | | | | | | | | |
| | **Microclimate** | Heat stress | THI > 78 | With insulation | Medium | Medium | 10% | 40% | 70% | Medium | 5% | 10% | 20% | High | Medium | 7% | 5% | 11% | High |
| | | | | Without insulation | High | Medium | 25% | 50% | 80% | Medium | 5% | 20% | 30% | High | High | 16% | 9% | 21% | High |
| | | | | With adequate ventilation | Medium | Medium | 10% | 40% | 70% | Medium | 5% | 15% | 30% | High | Medium | 11% | 6% | 17% | High |
| | | | | Without adequate ventilation | High | Medium | 10% | 60% | 100% | Medium | 5% | 20% | 25% | High | High | 19% | 12% | 23% | High |
| | | | | Open feedlot (without shade) | High | Short | 40% | 60% | 100% | Medium | 5% | 15% | 30% | High | Medium | 16% | 8% | 24% | High |
| | | | | Feedlot with shade | Medium | Short | 10% | 20% | 50% | Medium | 10% | 15% | 30% | High | Low | 8% | 6% | 12% | High |
| | | | | Cattle at pasture | Medium | Short | 25% | 40% | 80% | Medium | 1% | 5% | 10% | High | Low | 4% | 2% | 6% | High |
| | | Cold stress | Ambient T° < -10 °C | Indoors | Low | Medium | 10% | 20% | 40% | Medium | 5% | 20% | 30% | High | Low | 8% | 4% | 11% | High |
| | | | | Outdoors | Medium | Medium | 20% | 40% | 60% | Medium | 5% | 5% | 10% | High | Medium | 3% | 3% | 4% | High |
| | | | Chronic cold/undernutrition | Cattle at pasture | Medium | Medium | 60% | 80% | 100% | Medium | 1% | 5% | 10% | High | Medium | 5% | 2% | 8% | High |
| | | Respiratory disease | Air space < 20 $m^3$/animal | With adequate ventilation | High | Medium | 10% | 20% | 40% | Low | 15% | 25% | 50% | High | High | 11% | 7% | 16% | High |
| | | | | Without adequate ventilation | High | Medium | 10% | 50% | 70% | Low | 5% | 15% | 25% | High | High | 11% | 6% | 15% | High |
| | | | Air quality | Ammonia > 20 ppm | Medium | Long | 30% | 50% | 80% | Medium | 10% | 10% | 30% | High | High | 10% | 8% | 15% | High |
| | **Pen design** | Lameness | Concrete floors | | Medium | Long | 5% | 10% | 20% | Medium | 30% | 60% | 75% | High | High | 12% | 9% | 14% | High |
| | | | Rubberised floor | | Medium | Long | 1% | 2% | 10% | Medium | 1% | 3% | 5% | High | High | 0% | 0% | 0% | High |
| | | | Bedded floors | | High | Medium | 1% | 10% | 20% | Medium | 5% | 20% | 30% | High | High | 4% | 2% | 5% | High |
| | | Abnormal behaviour/aggression | Concrete floors | | Medium | Long | 0% | 2% | 10% | High | 30% | 60% | 75% | High | High | 6% | 4% | 7% | High |
| | | | Rubberised floor | | Medium | Long | 0% | 2% | 10% | High | 1% | 3% | 5% | High | High | 0% | 0% | 0% | High |
| | | | Bedded floors | | Medium | Long | 0% | 0% | 5% | High | 5% | 20% | 30% | High | High | 1% | 1% | 1% | High |
| | | Musculoskeletal disorders | Tethering | | Medium | Long | 10% | 20% | 40% | High | 2% | 5% | 10% | High | High | 2% | 1% | 3% | High |
| | | Behavioural restriction | Tethering | | High | Long | 100% | 100% | 100% | Low | 2% | 5% | 10% | High | Very High | 5% | 3% | 8% | High |
| | | | Restricted space at feeders | | Medium | Long | 80% | 90% | 100% | Low | 1% | 5% | 10% | High | High | 5% | 2% | 8% | High |
| | **Space allowance** | Behavioural restriction | Insufficient space allowance | Floor space < 3 $m^2$/animal | Medium | Long | 90% | 95% | 100% | Low | 20% | 40% | 60% | High | High | 40% | 28% | 52% | High |
| | | Aggression and injury | Insufficient space allowance | Floor space < 3 $m^2$/animal | Medium | Long | 25% | 50% | 70% | Medium | 20% | 40% | 60% | High | High | 28% | 19% | 37% | High |
| | | Respiratory disease | Insufficient space allowance | Floor space < 3 $m^2$/animal | High | Medium | 15% | 50% | 70% | High | 20% | 40% | 60% | High | High | 28% | 19% | 37% | High |
| | | Lack of cleanliness | Insufficient space allowance | Floor space < 3 $m^2$/animal | Low | Long | 40% | 60% | 100% | Medium | 20% | 40% | 60% | High | Medium | 40% | 28% | 53% | High |
| **Management** | | | | | | | | | | | | | | | | | | | |
| | **Thermoregulation** | Heat stress | Acute heat stress | Intensive concentrates | Medium | Medium | 10% | 30% | 50% | Low | 1% | 6% | 15% | High | Medium | 3% | 1% | 6% | High |
| | | | | Forage + concentrates | Medium | Medium | 20% | 50% | 70% | Low | 5% | 20% | 30% | High | Medium | 14% | 8% | 19% | High |

| TARGET POPULATION: Beef cattle | | | | | Risk Assessment | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Section | Sub-section | Hazard identification | | | Consequence characterisation | | | | | | Exposure assessment | | | | Risk characterisation | | | | |
| | | Welfare outcome | Hazard description | Hazard specification | Magnitude | | Probability of welfare consequence given exposure to the factor | | | Uncertainty | Probability of exposure | | | Uncertainty | Magnitude | Probability of the event | | | Uncertainty |
| | | | | | Intensity | Duration | min | ML | max | | min | ML | max | | | ML | CI5% | CI95% | |
| | | | | Cattle at pasture | Medium | Medium | 5% | 20% | 30% | Medium | 1% | 5% | 10% | High | Medium | 2% | 1% | 2% | High |
| | Mutilations | Pain | Thermocautery disbudding | No pain management | High | Short | 100% | 100% | 100% | Low | 8% | 9% | 10% | Low | Medium | 9% | 8% | 10% | Low |
| | | | | With local anaesthesia | Medium | Short | 100% | 100% | 100% | Low | 2% | 3% | 4% | Low | Low | 3% | 2% | 4% | Low |
| | | | | With local anaesthesia plus analgesia | Low | Short | 100% | 100% | 100% | Low | 1% | 2% | 3% | Low | Very Low | 2% | 1% | 3% | Low |
| | | | Chemical cautery disbudding | No pain management | High | Medium | 100% | 100% | 100% | Low | 7% | 8% | 9% | Low | High | 8% | 7% | 9% | Low |
| | | | | With local anaesthesia | Medium | Medium | 100% | 100% | 100% | Low | 2% | 3% | 4% | Low | Medium | 3% | 2% | 4% | Low |
| | | | | With local anaesthesia plus analgesia | Low | Medium | 100% | 100% | 100% | Low | 1% | 2% | 3% | Low | Low | 2% | 1% | 3% | Low |
| | | | Dehorning | No pain management | High | Medium | 100% | 100% | 100% | Low | 6% | 7% | 8% | Low | High | 7% | 6% | 8% | Low |
| | | | | With local anaesthesia | Medium | Medium | 100% | 100% | 100% | Low | 1% | 2% | 3% | Low | Medium | 2% | 1% | 3% | Low |
| | | | | With local anaesthesia plus analgesia | Low | Short | 100% | 100% | 100% | Low | 4% | 5% | 6% | Low | Very Low | 5% | 4% | 6% | Low |
| | | | Clamp castration < 2 months | No pain management | High | Medium | 100% | 100% | 100% | Low | 1% | 3% | 5% | High | High | 3% | 2% | 4% | High |
| | | | | With local anaesthesia | Medium | Medium | 100% | 100% | 100% | Low | 1% | 1% | 2% | High | Medium | 1% | 1% | 1% | High |
| | | | | With local anaesthesia plus analgesia | Low | Medium | 100% | 100% | 100% | Low | 0% | 0% | 1% | High | Low | 0% | 0% | 0% | High |
| | | | Clamp castration > 2 months | No pain management | High | Medium | 100% | 100% | 100% | Low | 1% | 5% | 7% | High | High | 5% | 3% | 6% | High |
| | | | | With local anaesthesia | Medium | Medium | 100% | 100% | 100% | Low | 1% | 3% | 5% | High | Medium | 3% | 2% | 4% | High |
| | | | | With local anaesthesia plus analgesia | Medium | Medium | 100% | 100% | 100% | Low | 1% | 1% | 2% | High | Medium | 1% | 1% | 1% | High |
| | | | Ring castration < 2 months | No pain management | High | Medium | 100% | 100% | 100% | Low | 1% | 5% | 7% | High | High | 5% | 3% | 6% | High |
| | | | | With local anaesthesia | Medium | Medium | 100% | 100% | 100% | Low | 1% | 1% | 2% | High | Medium | 1% | 1% | 1% | High |
| | | | | With local anaesthesia plus analgesia | Low | Medium | 100% | 100% | 100% | Low | 0% | 0% | 1% | High | Low | 0% | 0% | 0% | High |
| | | | Surgical castration > 2 months | No pain management | High | Medium | 100% | 100% | 100% | Low | 1% | 3% | 5% | High | High | 3% | 2% | 4% | High |
| | | | | With local anaesthesia | High | Medium | 100% | 100% | 100% | Low | 1% | 3% | 5% | High | High | 3% | 2% | 4% | High |

| TARGET POPULATION: Beef cattle | | | | | Risk Assessment | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Section | Sub-section | Hazard identification | | | Consequence characterisation | | | | | | Exposure assessment | | | | Risk characterisation | | | | |
| | | Welfare outcome | Hazard description | Hazard specification | Magnitude | | Probability of welfare consequence given exposure to the factor | | | Uncertainty | Probability of exposure | | | Uncertainty | Magnitude | Probability of the event | | | Uncertainty |
| | | | | | Intensity | Duration | min | ML | max | | min | ML | max | | | ML | CI5% | CI95% | |
| | | | | With local anaesthesia plus analgesia | Medium | Medium | 100% | 100% | 100% | Low | 1% | 3% | 5% | High | Medium | 3% | 2% | 4% | High |
| | | Pain and disease | Surgical spaying | | Medium | Medium | 100% | 100% | 100% | Medium | 0% | 1% | 1% | High | Medium | 1% | 0% | 1% | High |
| | | Pain and behavioural deprivation | Partial glossectomy | | High | Long | 100% | 100% | 100% | Low | 0% | 1% | 1% | High | Very High | 1% | 0% | 1% | High |
| | | Pain | Tail tip docking | Without anaesthesia | High | Medium | 100% | 100% | 100% | Low | 1% | 2% | 5% | High | High | 2% | 1% | 4% | High |
| | **Genetics** | Leg problems, respiratory disease | Hyper muscularity | All systems, specific breeds | Medium | Long | 50% | 70% | 90% | Medium | 2% | 5% | 7% | Medium | High | 4% | 3% | 6% | Medium |
| | **Nutrition and feeding** | Acute ruminal acidosis | Acute grain overload | All systems | High | Medium | 1% | 5% | 10% | Low | 1% | 2% | 3% | High | High | 0% | 0% | 0% | High |
| | | Subacute ruminal acidosis | High starch/fibre ratio in diet | Intensive concentrates | Medium | Long | 20% | 40% | 80% | Medium | 15% | 25% | 50% | Medium | High | 22% | 15% | 31% | Medium |
| | | | | Forage + concentrates | Medium | Long | 2% | 10% | 30% | Medium | 5% | 15% | 25% | Medium | High | 4% | 3% | 6% | Medium |
| | | Bloat | Cattle at high legume pasture | | High | Medium | 1% | 2% | 5% | Medium | 1% | 2% | 5% | Medium | High | 0% | 0% | 0% | Medium |
| | | | Intensive concentrates | | High | Medium | 5% | 8% | 10% | Medium | 15% | 25% | 50% | High | High | 3% | 2% | 4% | High |
| | | Laminitis | Intensive concentrates | | High | Long | 5% | 10% | 15% | Medium | 15% | 25% | 50% | Medium | Very High | 4% | 3% | 6% | Medium |
| | | | Forage + concentrates | | High | Long | 0% | 2% | 5% | Medium | 5% | 65% | 80% | Medium | Very High | 3% | 2% | 4% | Medium |
| | | Para- and hyperkeratosis | Intensive concentrates | | Medium | Long | 20% | 50% | 80% | Medium | 15% | 25% | 50% | Medium | High | 21% | 14% | 31% | Medium |
| | | | Forage + concentrates | | Medium | Long | 0% | 10% | 20% | Medium | 5% | 65% | 80% | Medium | High | 12% | 7% | 15% | Medium |
| | | Liver abscess | Intensive concentrates | | Medium | Long | 0% | 15% | 30% | Medium | 15% | 25% | 50% | Medium | High | 8% | 5% | 12% | Medium |
| | | | Forage + concentrates | | Medium | Long | 0% | 4% | 10% | Medium | 5% | 65% | 80% | Medium | High | 6% | 3% | 8% | Medium |
| | | Skeletal disorders | Intensive concentrates | | Medium | Long | 0% | 5% | 10% | High | 10% | 25% | 50% | High | High | 3% | 2% | 4% | High |
| | | Undernutrition | Cattle at pasture | | High | Long | 50% | 70% | 100% | Medium | 5% | 10% | 30% | High | Very High | 12% | 7% | 20% | High |
| | | Mineral deficiencies | Magnesium | Cattle at deficient pasture | High | Long | 1% | 3% | 10% | Medium | 0% | 2% | 4% | High | Very High | 0% | 0% | 0% | High |
| | | | Copper/molybdenum | Cattle at deficient pasture | Medium | Long | 8% | 15% | 25% | Medium | 0% | 1% | 3% | High | High | 0% | 0% | 1% | High |
| | | | Phosphorus | Cattle at deficient pasture | Medium | Long | 8% | 15% | 25% | Medium | 0% | 3% | 6% | High | High | 1% | 0% | 1% | High |
| | **Feed-related behavioural disorders** | Tongue rolling | Intensive concentrates | | Medium | Long | 25% | 40% | 55% | Medium | 15% | 25% | 50% | High | High | 15% | 10% | 21% | High |
| | | | Forage + concentrates | | Medium | Long | 1% | 4% | 8% | Medium | 5% | 65% | 80% | High | High | 5% | 3% | 6% | High |
| | | Urine drinking | Intensive concentrates | | Medium | Long | 10% | 20% | 40% | Medium | 15% | 25% | 50% | High | High | 11% | 7% | 16% | High |
| | | | Forage + concentrates | | Medium | Long | 1% | 5% | 10% | Medium | 5% | 65% | 80% | High | High | 6% | 3% | 8% | High |
| | | Toxaemia | Moulds + bacteria | Poor silage + concentrates | High | Medium | 20% | 30% | 40% | High | 5% | 10% | 15% | High | High | 4% | 3% | 5% | High |
| | **Grouping of animals** | Respiratory disease | Co-mingling in feedlot | With pre-conditioning | Medium | Medium | 5% | 10% | 15% | Low | 1% | 5% | 8% | High | Medium | 1% | 0% | 1% | High |
| | | | | Without pre-conditioning | High | Medium | 30% | 40% | 50% | Low | 10% | 20% | 40% | High | High | 11% | 7% | 16% | High |

| TARGET POPULATION: Beef cattle | | | | | Risk Assessment | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Section | Sub-section | Hazard identificatiom | | | Consequence characterisation | | | | | | Exposure assessment | | | | Risk characterisation | | | | |
| | | Welfare outcome | Hazard description | Hazard specification | Magnitude | | Probability of welfare consequence given exposure to the factor | | | Uncertainty | Probability of exposure | | | Uncertainty | Magnitude | Probability of the event | | | Uncertainty |
| | | | | | Intensity | Duration | min | ML | max | | min | ML | max | | | ML | CI5% | CI95% | |
| | **Weaning** | Stress and frustration | Keeping newly weaned beef calves in sight of mothers | | Medium | Medium | 100% | 100% | 100% | High | 1% | 5% | 10% | High | Medium | 5% | 2% | 8% | High |
| | | | Complete separation without visual contact | | Medium | Medium | 100% | 100% | 100% | High | 30% | 40% | 50% | High | Medium | 40% | 34% | 46% | High |
| | | Stress and fear | Mixing during fattening | | Medium | Medium | 20% | 30% | 40% | Low | 10% | 25% | 40% | High | Medium | 10% | 6% | 14% | High |
| | | Frustration | Use of bar/grids that prevent from mounting | | Medium | Medium | 40% | 60% | 80% | Medium | 1% | 5% | 8% | High | Medium | 4% | 2% | 6% | High |
| | | Injuries | Aggression/mounting animals | | Medium | Long | 5% | 10% | 15% | Medium | 40% | 60% | 70% | High | High | 9% | 7% | 10% | High |
| | **Human-animal interaction** | Fear and stress | Interaction with humans | Unrained stockpeople | Medium | Medium | 50% | 75% | 90% | Medium | 10% | 20% | 30% | High | Medium | 18% | 13% | 24% | High |
| | | | | Unfamiliar stockpeople | Medium | Medium | 50% | 75% | 90% | Medium | 5% | 10% | 15% | High | Medium | 9% | 6% | 12% | High |
| | | | Moving animals | With use of electrical prods or other means of coercion | High | Short | 100% | 100% | 100% | Medium | 20% | 50% | 80% | High | Medium | 50% | 31% | 68% | High |
| **Disease management** | | | | | | | | | | | | | | | | | | | |
| | **Respiratory disease** | Respiratory disease | No vaccination against respiratory virus | | High | Medium | 10% | 25% | 40% | Medium | 5% | 20% | 40% | High | High | 8% | 4% | 13% | High |
| | | | Vaccination only at entering feedlot | | High | Medium | 5% | 15% | 25% | Medium | 10% | 30% | 50% | High | High | 7% | 4% | 11% | High |
| | | | Delay in BRD diagnosis | With metaphylaxis | Medium | Medium | 1% | 5% | 10% | Low | 5% | 25% | 40% | High | Medium | 2% | 1% | 3% | High |
| | | | | No metaphylaxis | High | Medium | 15% | 25% | 40% | Low | 40% | 65% | 80% | High | High | 26% | 20% | 30% | High |
| | | | Prior transport | | High | Medium | 5% | 15% | 25% | Medium | 80% | 90% | 95% | Low | High | 22% | 21% | 23% | Medium |
| | | Chronic pneumonia - ill thrift | Failure to treat or cull | | High | Long | 80% | 90% | 95% | Medium | 1% | 1% | 2% | Medium | Very High | 1% | 1% | 1% | Medium |
| | **Other diseases** | Disease | No planned herd health programme | | High | Long | 10% | 25% | 40% | Medium | 50% | 80% | 90% | High | Very High | 31% | 25% | 35% | High |
| | | Death and injury | No protection from predators | | High | Long | 1% | 2% | 5% | Medium | 1% | 2% | 3% | Medium | Very High | 0% | 0% | 0% | Medium |
| | | Parasitism and undernutrition | No pasture management | | High | Long | 20% | 40% | 60% | Medium | 2% | 4% | 6% | High | Very High | 2% | 2% | 3% | High |

**Table 14:** Calves kept in intensive farming systems risk assessment: results.

| TARGET POPULATION: Calves | | | | | Risk assessment | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Section | Sub-section | Hazard identification | | | Consequence characterisation | | | | | | Exposure assessment | | | | Risk characterisation | | | | |
| | | Welfare outcome | Hazard description | Hazard specification | Magnitude | | Probability of welfare consequence given exposure to the factor | | | Uncertainty | Probability of exposure | | | Uncertainty | Magnitude | Probability of the event | | | Uncertainty |
| | | | | | Intensity | Duration | min | ML | max | | min | ML | max | | | ML | CI5% | CI95 % | |
| Housing | | | | | | | | | | | | | | | | | | | |
| | Flooring and bedding material | Discomfort | Type of floor | Slatted flooring (concrete) | Medium | Long | 50% | 70% | 85% | Medium | 25% | 30% | 40% | Low | High | 21% | 17% | 26% | Medium |
| | | | | Slatted flooring (concrete with rubber surface) | Low | Long | 15% | 25% | 35% | Medium | 1% | 1% | 2% | Low | Medium | 0% | 0% | 0% | Medium |
| | | | | Perforated rubber mat flooring | Low | Long | 15% | 25% | 35% | Medium | 1% | 1% | 2% | Low | Medium | 0% | 0% | 0% | Medium |
| | | | | Wooden slats | Medium | Long | 50% | 70% | 85% | High | 60% | 70% | 80% | Low | High | 48% | 40% | 57% | High |
| | | Injury | Type of floor | Slatted flooring (concrete) | Medium | Long | 10% | 20% | 30% | Medium | 25% | 30% | 40% | Low | High | 6% | 4% | 8% | Medium |
| | | | | Slatted flooring (concrete with rubber surface) | Medium | Long | 0% | 1% | 2% | Medium | 1% | 1% | 2% | Low | High | 0% | 0% | 0% | Medium |
| | | | | Perforated rubber mat flooring | Medium | Long | 0% | 1% | 2% | Medium | 1% | 1% | 2% | Low | High | 0% | 0% | 0% | Medium |
| | | | | Wooden slats | Medium | Long | 5% | 10% | 20% | Medium | 60% | 70% | 80% | Low | High | 7% | 5% | 11% | Medium |
| | Temperature, ventilation and air hygiene | Heat stress | THI > 78 | Wind < 0.5 m/s | High | Medium | 60% | 80% | 100% | Medium | 10% | 20% | 30% | Medium | High | 16% | 11% | 22% | Medium |
| | | | | Wind > 0.5 m/s | Medium | Medium | 15% | 25% | 35% | Medium | 2% | 5% | 10% | Medium | Medium | 1% | 1% | 2% | Medium |
| | | Cold stress | Ambient T° < 5 °C | Dry lying area | Low | Medium | 2% | 5% | 10% | Medium | 1% | 1% | 2% | Medium | Low | 0% | 0% | 0% | Medium |
| | | | | Wet lying area | Medium | Medium | 30% | 70% | 90% | Medium | 1% | 1% | 2% | Medium | Medium | 1% | 0% | 1% | Medium |
| | | Respiratory disease | Air volume | Air volume per animal < 10 $m^3$ | High | Long | 10% | 25% | 40% | Medium | 30% | 40% | 60% | High | Very High | 10% | 6% | 15% | High |
| | | | Air quality | Ammonia > 20 ppm | High | Long | 5% | 25% | 40% | Medium | 5% | 10% | 20% | High | Very High | 2% | 1% | 4% | High |
| | Degree of social contact | Respiratory disease | Group size | < 6 animals per group | High | Long | 10% | 20% | 40% | High | 70% | 80% | 90% | Low | Very High | 17% | 11% | 25% | High |
| | | | | > 15 animals per group | High | Long | 20% | 30% | 60% | High | 10% | 20% | 30% | Low | Very High | 6% | 4% | 10% | High |
| | | Respiratory disease and neonatal diarrhoea | Early group housing | Individual pen until 3 to 8 weeks after birth | High | Medium | 5% | 10% | 15% | Medium | 50% | 70% | 85% | Medium | High | 7% | 5% | 9% | Medium |
| | | | | Collective pen immediately after birth | High | Medium | 15% | 25% | 35% | Medium | 20% | 28% | 35% | Medium | High | 7% | 5% | 9% | Medium |
| | | | | With the dam after birth until 3 to 8 weeks after birth | High | Medium | 2% | 5% | 10% | Medium | 1% | 2% | 4% | High | High | 0% | 0% | 0% | High |
| | | Disturbed feeding behaviour | Feeding places solid feed lower than calves per pen | > 4 calves per feeder or feeding place | Medium | Long | 60% | 80% | 90% | Low | 5% | 10% | 15% | Medium | High | 8% | 5% | 11% | High |
| | | Disturbed resting behaviour | Space allowance | < 1.5 $m^2$/animal | Medium | Long | 30% | 50% | 70% | Medium | 90% | 95% | 98% | Low | High | 47% | 35% | 59% | Medium |
| | | | | > 1.5 $m^2$/animal | Low | Long | 5% | 10% | 15% | Medium | 2% | 5% | 10% | Low | Medium | 1% | 0% | 1% | Medium |

| TARGET POPULATION: Calves | | | | | Risk assessment | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Section | Sub-section | Hazard identification | | | Consequence characterisation | | | | | | Exposure assessment | | | | Risk characterisation | | | | |
| | | Welfare outcome | Hazard description | Hazard specification | Magnitude | | Probability of welfare consequence given exposure to the factor | | | Uncertainty | Probability of exposure | | | Uncertainty | Magnitude | Probability of the event | | | Uncertainty |
| | | | | | Intensity | Duration | min | ML | max | | min | ML | max | | | ML | CI5% | CI95 % | |
| **Feeding and housing systems, weaning strategies and quality of solid and liquid feed** | | | | | | | | | | | | | | | | | | | |
| | **Feeding systems** | Disturbed glucose metabolism | Low feeding frequency milk replacer during fattening | Twice daily | Medium | Long | 40% | 50% | 60% | Low | 40% | 40% | 50% | Medium | High | 21% | 18% | 24% | High |
| | | | | > Twice daily | Medium | Long | 10% | 20% | 30% | Low | 20% | 30% | 40% | Medium | High | 6% | 4% | 8% | High |
| | | Diarrhoea | High levels of milk replacer during fattening | | High | Medium | 20% | 30% | 60% | Medium | 60% | 70% | 80% | Low | High | 23% | 16% | 33% | Medium |
| | | "Ruminal" drinking | High levels of milk replacer during fattening | Trough/Bucket | Medium | Long | 5% | 10% | 15% | Medium | 50% | 60% | 70% | High | High | 6% | 4% | 8% | High |
| | | | | Teat feeders | Medium | Long | 1% | 3% | 5% | Medium | 5% | 10% | 15% | Low | High | 0% | 0% | 0% | Medium |
| | | Poor body condition | No proper standardisation of calves within pens based on BW and drinking speed during fattening | | High | Long | 50% | 80% | 90% | High | 3% | 5% | 20% | High | Very High | 5% | 3% | 10% | High |
| | | Dehydration or thirst | Restricted amount of water next to milk replacer during hot weather or disease during fattening | | High | Medium | 40% | 50% | 60% | Medium | 5% | 20% | 40% | High | High | 10% | 5% | 16% | High |
| | **Feeding pre-weaning** | Health problems | Inadequate colostrum | | High | Long | 40% | 50% | 80% | Medium | 20% | 30% | 50% | Medium | Very High | 17% | 11% | 24% | Medium |
| | | | Contaminated colostrum | Septicaemia and other diseases | High | Long | 50% | 60% | 70% | High | 5% | 10% | 15% | High | Very High | 6% | 4% | 8% | High |
| | | | Low quality liquid feed | Vegetable protein | Medium | Long | 5% | 30% | 70% | Medium | 30% | 30% | 50% | High | High | 11% | 4% | 18% | High |
| | | | | Low fat in cold weather | Medium | Long | 5% | 5% | 12% | Medium | 5% | 10% | 15% | High | High | 1% | 0% | 1% | High |
| | | | Low feeding level milk | < 20 % of body weight/day first 3 weeks after birth | Medium | Long | 30% | 40% | 60% | High | 5% | 10% | 15% | High | High | 4% | 3% | 6% | High |
| | | | Milk too cold | | Medium | Short | 30% | 40% | 50% | High | 5% | 10% | 15% | High | Low | 4% | 3% | 5% | High |
| | **Weaning strategies** | Reduced pre-weaning growth | Abrupt weaning | No stepwise weaning | Medium | Medium | 10% | 30% | 50% | High | 10% | 20% | 30% | High | Medium | 6% | 3% | 9% | High |
| | | Reduced post-weaning solid feed intake, reduced rumen development | Weaning too early | | High | Medium | | 50% | 70% | Medium | 10% | 25% | 40% | High | High | 0% | 0% | 0% | High |
| | **Quality of solid and liquid feed (white veal)** | Clinical signs of anaemia, Hb < 4.5 mmol/l | Restricted dietary iron supply during fattening | Iron < 50 ppm | High | Long | 10% | 20% | 60% | Medium | 50% | 70% | 100% | Low | Very High | 17% | 9% | 30% | Medium |
| | | Health problems | Restricted solid feed supply next to milk replacer during fattening | < 500 g DM/animal/day | High | Long | 15% | 30% | 50% | Medium | 30% | 50% | 100% | Low | Very High | 16% | 9% | 27% | Medium |
| | | Digestive system disorders | Unbalanced solid feed next to milk replacer during fattening | Roughage < 25 % of DM | High | Long | 15% | 30% | 50% | Medium | 40% | 60% | 100% | Low | Very High | 19% | 12% | 29% | Medium |
| | | Abnormal oral behaviours | Restricted and unbalanced solid feed next to milk replacer during fattening | | Medium | long | 10% | 20% | 30% | Medium | 70% | 80% | 90% | Medium | High | 16% | 11% | 21% | Medium |
| | | Digestive system disorders | Low quality milk replacer during fattening | Too much vegetable protein | High | Long | 40% | 50% | 60% | Medium | 30% | 50% | 60% | High | Very High | 24% | 19% | 30% | High |

| TARGET POPULATION: Calves | | | | | Risk assessment | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Section | Sub-section | Hazard identification | | | Consequence characterisation | | | | | | Exposure assessment | | | | Risk characterisation | | | | |
| | | Welfare outcome | Hazard description | Hazard specification | Magnitude | | Probability of welfare consequence given exposure to the factor | | | Uncertainty | Probability of exposure | | | Uncertainty | Magnitude | Probability of the event | | | Uncertainty |
| | | | | | Intensity | Duration | min | ML | max | | min | ML | max | | | ML | CI5% | CI95 % | |
| | **Nutrition and feeding** | Digestive disorders:<br>Ruminal acidosis | Forage + concentrates + by-products during fattening | | High | Medium | 10% | 20% | 30% | Medium | 20% | 30% | 40% | Medium | High | 6% | 4% | 8% | Medium |
| | | Bloat | Forage + concentrates + by-products during fattening | | High | Medium | 10% | 20% | 30% | Medium | 20% | 30% | 40% | Medium | High | 6% | 4% | 8% | Medium |
| | | Para- and Hyperkeratosis | Forage + concentrates + by-products during fattening | | Medium | Long | 20% | 30% | 40% | Medium | 20% | 30% | 40% | Medium | High | 9% | 7% | 12% | Medium |
| | | Abnormal oral behaviours | Forage + concentrates + by-products during fattening | | Medium | Long | 5% | 10% | 15% | Medium | 20% | 30% | 40% | Medium | High | 3% | 2% | 4% | Medium |
| | | Health problems due to undesirable substances in feeds | Moulds (*Fusarium*), Bacteria (*Listeria*) in feed during fattening | | High | Medium | 40% | 50% | 60% | Medium | 1% | 5% | 10% | High | High | 3% | 1% | 4% | High |
| | | Abnormal oral behaviours | Restricted and unbalanced solid feed next to milk replacer during fattening | | Medium | Long | 30% | 40% | 50% | Medium | 50% | 60% | 70% | Medium | High | 24% | 20% | 29% | Medium |
| | | Reduced post-weaning solid feed intake, reduced rumen development | Weaning too early | | Medium | Medium | 60% | 70% | 80% | High | 10% | 20% | 30% | High | Medium | 14% | 10% | 19% | High |
| **Human-animal relationships** | | | | | | | | | | | | | | | | | | | |
| | **Human-animal interaction** | Fear and stress | Interaction with humans | Untrained stockpeople<br>Approach test, distance, etc. | Medium | Medium | 50% | 75% | 90% | Medium | 10% | 20% | 30% | High | Medium | 15% | 10% | 20% | High |
| | | | | Not familiar stockpeople<br>Approach test, distance, etc. | Medium | Medium | 50% | 75% | 90% | Medium | 5% | 10% | 15% | High | Medium | 7% | 5% | 10% | High |
| | | | Moving animals | With use of electrical prods or other means of coercion<br>Approach test, distance, etc. | High | Short | 100% | 100 % | 100% | Medium | 10% | 20% | 30% | High | Medium | 20% | 14% | 26% | High |
| **Disease and management** | | | | | | | | | | | | | | | | | | | |
| | **Monitoring of Hb and treatment with iron (white veal)** | Infection and disease, iron overload | General iron treatment young calves | All calves receive iron at start fattening period | High | Medium | 5% | 10% | 15% | Medium | 10% | 20% | 30% | High | High | 2% | 1% | 3% | High |
| | | Clinical signs of anaemia, Hb < 4.5 mmol/l | Inaccurate monitoring of iron status - haemoglobin | Only at the beginning and in the middle of fattening period, group-wise rather than individually | High | Medium | 20% | 30% | 40% | Medium | 30% | 40% | 50% | Medium | High | 12% | 9% | 15% | Medium |
| | **Composition of calf batches** | Disease | Calves from different farms and/or countries | | High | Long | 70% | 80% | 90% | High | 90% | 100% | 100% | Medium | Very High | 79% | 72% | 85% | High |
| | | | Light weight on arrival | < 45 kg | High | Long | 20% | 30% | 40% | Low | 5% | 10% | 15% | low | Very High | 3% | 2% | 4% | Low |
| | **Group composition** | Disease | Rotation of calves across pens - standardisation of BW and drinking speed | | High | Long | 20% | 30% | 40% | Medium | 50% | 60% | 70% | Low | Very High | 18% | 14% | 22% | Medium |
| | **Management** | Diarrhoea | No dam vaccination against diarrhoea causing agents | | Medium | Medium | 5% | 20% | 30% | Medium | 20% | 30% | 50% | High | Medium | 6% | 3% | 9% | High |
| | | Omphalitis, septicaemia, polyarthritis | No umbilical disinfection | | High | Long | 2% | 5% | 10% | High | 20% | 50% | 60% | High | Very High | 2% | 1% | 4% | High |
| | | Pain, ulcerations, dehydration, eye lesions | Poor management of severely sick calves | | High | Medium | 50% | 75% | 90% | Medium | 1% | 2% | 3% | Medium | High | 1% | 1% | 2% | Medium |

| TARGET POPULATION: Calves | | | | | Risk assessment | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Section | Sub-section | Hazard identification | | | Consequence characterisation | | | | | | Exposure assessment | | | | Risk characterisation | | | | |
| | | Welfare outcome | Hazard description | Hazard specification | Magnitude | | Probability of welfare consequence given exposure to the factor | | | Uncertainty | Probability of exposure | | | Uncertainty | Magnitude | Probability of the event | | | Uncertainty |
| | | | | | Intensity | Duration | min | ML | max | | min | ML | max | | | ML | CI5% | CI95 % | |
| | | Diarrhoea, septicaemia | Poor hygiene - buckets, teats, filters | | Medium | Medium | 5% | 10% | 15% | Medium | 10% | 15% | 25% | High | Medium | 2% | 1% | 2% | High |
| | | Pink-eye, maggots | No insect control | | Medium | Medium | 2% | 5% | 7% | Medium | 30% | 50% | 70% | High | Medium | 2% | 1% | 3% | High |
| | | Diarrhoea, bacteria resistance to anti-microbials, other disease | Use of waste milk | | Low | Medium | 2% | 5% | 7% | High | 30% | 50% | 70% | High | Low | 2% | 2% | 3% | High |
| | | Disease, dehydration | No routine inspection of young animals | | Medium | Medium | 1% | 3% | 5% | Medium | 10% | 25% | 40% | High | Medium | 1% | 0% | 1% | High |

## C. GLOSSARY AND ABBREVIATIONS

**Animal-based measure:** a response of an animal or an effect on an animal used to assess its welfare. It can be taken directly from the animal or indirectly, and includes the use of animal records.

**Bloat (Ruminal tympany)**: is an abnormal distension of the rumen and reticulum caused by excessive retention of the gases of fermentation.

**Bovine Respiratory Disease (BRD):** is a general term for a condition that can affect both the upper and lower respiratory tract. Since differential diagnosis is complex it has become common practice to devise treatments and control programmes which deal with several diseases as a group.

**Bullers:** can be defined as steers that will stand to be ridden. Bullers are a significant problem throughout the cattle feeding industry. Late-1990s data indicates that in most feedyards, 1-4 % of all steers are identified as bullers.

**Castration:** is the removal of the gonads. Although the word is more commonly used to designate the removal of the testicles, it can also be applied to females (see Spaying). Three methods are frequent in male cattle castration – ring or band; clamp or Burdizzo; and surgical castration.

**Co-mingling:** mixing of animals from different sources.

**Dehorning:** or horn amputation, is the removal of the visible and palpated horns after they have formed. Dehorning can be carried out at any stage from 3-4 months of age. In adult cattle it usually means the opening and exposure of the frontal sinus.

**Disbudding:** involves destroying the horn-producing cells (corium) of the horn bud, and it is undertaken on young calves usually under the age of 2-3 months. The methods used are thermocautery or hot-iron dehorning and chemical cautery with a strong alkali.

**DNA marker**: a specific DNA variation that can be tested for association with phenotypic characteristics (trait).

**Factor:** any aspect of the environment of the animal, in relation to housing and management, genetic selection of animals, transport and slaughter, which may have the potential to improve or impair the welfare of animals.

**Hazard:** a factor with the potential to cause poor welfare.

**Marker Assisted Management (MAM):** the process by which DNA marker information is used to assist in making management decisions, such as sorting cattle entering a feedlot based on their propensity to meet certain criteria as determined by a genetic test.

**Marker Assisted Selection (MAS):** the process by which DNA marker information is used to select parents for the next generation.

**Marker panel:** a combination of two or more DNA markers which are associated with a particular trait.

**Metabolisable Energy (ME) and Protein (MP) Systems:** provide the framework for describing the requirements and formulating diets in cattle.

**Neo-natal diarrhea:** undifferentiated diarrhoea of the newborn (under 15 days of age) for which an aetiologic diagnosis is not practical. It has bacterial, viral and diet causes but often two or more agents act in concert.

**Odds ratio (OR):** is the ratio of the odds of an event occurring in one group to the odds of it occurring in another group, for example, the occurrence of a disease.

**Perforating ulcer:** is the perforation by erosion of a pre-existing ulcer leading to peritonitis.

**Ruminal drinking:** accumulation of large amounts of milk replacer in the rumen due to fast feeding of high volumes of milk replacer, which may render calves susceptible to failure of the oesophageal (reticular) groove reflex.

**Spaying:** the word used for female castration, which is the removal of the ovaries.

**Subacute, Recurring Ruminal Acidosis (SARA):** is the consequence of feeding high grain diets to cows, which are adapted to digesting predominantly forage diets. SARA is characterised by daily episodes of low ruminal pH between 5.5 and 5.0.

**Tail docking:** the amputation of the terminal ¾ of the tail usually through the application of a tight rubber ring that leads to distal necrosis.

**Tail tip docking:** surgical amputation of the distal 5 cm of the tail.

**Temperature/humidity index (THI):** index that combines the effects of temperature and humidity on animals.

**Welfare:** The welfare of an individual is its state as regards its attempts to cope with its environment.

**Welfare measure:** A category of observation, recording or evaluation used to assess an animal's welfare. These are, in general animal-based but measures of housing and management may be predictors of changes in welfare.