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Scientific Opinion on

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 written procedure on the 24 of May 2006

EFSA-Q-2005-014

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Summary

EFSA has been requested by the European Commission 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.

In particular the Commission asked EFSA to update the findings of the Scientific Veterinary Committee (Animal Welfare Section) report, on the welfare of calves of 9 November 1995, in the light of more recent data on this issue. Where relevant the possible food safety implications of different farming systems should also be considered.

In this report a risk assessment was made and the relevant conclusions and recommendations are forming the scientific opinion by the AHAW Panel.

The SVC (1995) report contains information on measurements of welfare, needs of calves, descriptions of current housing systems, chapters on types of feed and feeding systems, weaning of calves, housing and pen design, climate, man-animal relationships, dehorning and castration. Further chapters covered economical considerations of systems and for improving welfare. In the report conclusions were made on general management, housing, food and water and economics.

The present report "The risks of poor welfare in intensive calf farming systems" is an update o the previous SVC report with the exception of economical aspects which are outside of the mandate for this report.

The various factors potentially affecting calves' health and welfare, already extensively listed in the 1995 report of the Scientific Veterinary Committee Animal Welfare section (SVC, 1995), are updated and subsequently systematically determined whether they constitute a potential hazard or risk. To the latter end their severity and likelihood of occurrence in animal (sub) populations were evaluated and associated risks to calf welfare estimated, hence providing the basis for risk managers to decide which measures could be contemplated to reduce or eliminate such risks. In line with the terms of reference the working group restricted itself to (in essence a qualitative) risk assessment

Although it is agreed that welfare and health of calves can be substantially affected in the course of and as a result of transport and slaughter, this report does not consider animal health and welfare aspects of calves during transport and slaughter but such information can be found in a recently issued comprehensive report of the Scientific Committee on Animal Health and Animal Welfare (SCAHAW), on "The welfare of animals during transport (details for horses, pigs, sheep and cattle)" which was adopted on 11 March 2002 (DG SANCO, 2002) and in the EFSA report "Welfare aspects of animal stunning and killing methods" (AHAW 04/027).

In relation with the food safety aspects, main foodborne hazards associated with calf farming are *Salmonella* spp., human pathogenic-verotoxigenic *Escherichia coli* (HP-VTEC), thermophilic *Campylobacter* spp., *Mycobacterium bovis*, *Taenia saginata cysticercus* and *Cryptosporidium parvum/Giardia duodenalis.* Present knowledge and published data are insufficient to produce a universal risk assessment enabling quantitative food safety categorization/ranking of different types of calf farming systems. Nevertheless, the main risk factors contributing to

increased prevalence/levels of the above foodborne pathogens, as well as generic principles for the risk reductions are known. The latter are based on the implementation of effective farm management (e.g. QA, husbandry, herd health plans, biosecurity) and hygiene measures (e.g. GFP-GHP).

In general, the conclusions made in the previous SVC report remain. However, recent research has provided for some additional conclusions.

The risk analysis is presented in the Tables of Annex 1. The Graphics in this table are not intented to represent numerical relationships but rather qualitative relations. In some instances the exposure could not be estimated due to lack of data, in which cases the risks where labelled "exposure data not available".

The following major and minor risks for poor animal health and welfare have been identified for one or several of the various husbandry systems considered:

Major risks
Inadequate colostrum intake – duration,
Inadequate ventilation, inappropriate airflow, airspeed, temperature for some husbandry systems
Exposure to pathogens causing respiratory and gastrointestinal disorders
Continuous restocking (No "all in – all out")
Mixing calves from different sources

Minor risks
Inadequate colostrum intake – quantity
Inadequate colostrum intake – quality
Insufficient access to water
Insufficiently balanced solid food
High humidity
Indoor draughts
Inadequate ventilation, inappropriate airflow, airspeed temperature for some husbandry sytems
Poor air quality (ammonia, bioaerosols and dust)
Poor floor conditions; gaps too large, too slippery, wet floor for lying, no bedding
Insufficient light for response to visual stimuli
Exposure to pathogens causing respiratory and gastrointestinal disorders
Poor response of farmer to health problems, especially necessary dietary changes
Lack of maternal care
Separation from the dam

For the following hazards there are not enough data available to assess the risks (labelled as "exposure data not available"):

Iron deficiency resulting in Haemoglobin levels below 4.5 mmol/l.
Allergenic proteins
Too rich diet (overfeeding)
Insufficient floor space allowance
Inadequate health monitoring
Inadequate haemoglobulin monitoring

The hazards of iron deficiency and insufficient floor space are considered to be very serious, the hazard of inadequate health monitoring is considered to be serious and the hazards of exposure to inadequate hemoglobin monitoring, allergenic proteins and too rich diet are considered to be moderately serious. For these hazards, there is no consensus on the exposure of calves mainly due to lack of data and that is why it is recommended that further studies should be made to provide evidence for an exposure assessment.

Regarding castration and dehorning (and disbudding) without anaesthetic drugs, there is a variation in relation to national legislation why the risk of poor welfare in relation to castration and dehorning has a wide range between countries.

1. Background

Council Directive 91/629/EEC[1] laying down minimum standards for the protection of calves as amended by Council Directive 97/2/EC[2] requires the Commission to submit to the Council a report, 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 Commission's report will be drawn up also taking into account socio-economic implications of different calf farming systems.

It should be noted that the Scientific Veterinary Committee (Animal Welfare Section) adopted a report on the welfare of calves[3] on 9 November 1995 which should serve as background to the Commission's request and preparation of the new EFSA scientific opinion. In particular the Commission requires EFSA to consider the need to update the findings of the Scientific Veterinary Committee's opinion in light of the availability of more recent data on this issue. Where relevant the possible food safety implications of different farming systems should also be considered.

2. Terms of Reference

EFSA has been requested by the European Commission 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.

In particular the Commission requires EFSA to update the findings of the Scientific Veterinary Committee (Animal Welfare Section) report on the welfare of calves of 9 November 1995 in light of more recent data on this issue. Where relevant the possible food safety implications of different farming systems should also be considered.

The mandate outlined above was accepted by the Panel on Animal Health and Welfare (AHAW) at the Plenary Meeting, on 14/15 March 2005. It was decided to establish a Working Group of AHAW experts (WG) chaired by one Panel member. Therefore the Plenary entrusted a scientific report and risk assessment to a working group under the Chairmanship of Prof. Bo Algers. The members of the working group are listed at the end of this report.

The Scientific Report is considered for the discussion to establish a risk assessment and the relevant conclusions and recommendations forming the Scientific Opinion by the AHAW Panel.

According to the mandate of EFSA, ethical, socio-economic, cultural and religious aspects are outside the scope of this scientific opinion.

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[1] OJ L 340, 11.12.1991, p. 28

[2] OJ L 25, 28.1.1997, p. 24

[3] http://europa.eu.int/comm/food/fs/sc/oldcomm4/out35_en.pdf

3. General Approach

In 1995, the Scientific Veterinary Committee of the European Commission published the Report on the Welfare of Calves.

The SVC (1995) report contains information on measurements of welfare, needs of calves, descriptions of current housing systems, chapters on types of feed and feeding systems, weaning of calves, housing and pen design, climate, man-animal relationships, dehorning and castration. Further chapters covered economic considerations of systems and for improving welfare. In the report conclusions were made on general management, housing, food and water and economics.

The present report "The risks of poor welfare in intensive calf farming systems" is an update of the previous SVC report with the exception of economic aspects which are out of the mandate for this report. This report represents an update of the previous SVC Report (1995) with a risk assessment perspective.

Factors which are important for calf welfare include housing (space and pen design, flooring and bedding material, temperature, ventilation and air hygiene), feeding (liquid feed, concentrates, roughage) and management (grouping, weaning, human-animal relations).

The measures used to assess welfare include behavioural and physiological measures, patho-physiological measures and clinical signs as well as production measures.

As explained in the glossary, in this report young bovines are called calves up to a maximum of eight months of age and veal is the meat of a calf. Countries with substantial production of veal are France, Italy, The Netherlands, Belgium, Spain and Germany. Significant veal production exists also in Portugal, Austria and Denmark, The production of white veal, from calves that have been fed predominantly milk replacer and which has a light colour, takes place largely in France, The Netherlands, Belgium and Italy. The EU subsidies scheme represents an important incentive for pink veal production. Most calves produced for further rearing are in France, Germany, UK, Ireland and Italy. The ways of keeping calves vary considerably from country to country and between breeds. Most dairy calves are separated from their dam at birth and artificially fed whereas calves from beef breeds generally suckle their dam.

According to EU statistics, in 2004 in the EU (25) 4,499,381 calves were reared for slaughter and 20,630,237 calves were reared for other reasons than slaughter. In total 755,226 tonnes of calf meat were produced in EU (15) which probably implies that about 825,000 tonnes were produced in EU (25) during 2004. Human consumption of meat from calves decreased slightly from 1995 to 2001 in EU (15).

3.1. Statement of purpose of the Risk Assessment Exercise

The working group set out to produce a document in which the various factors potentially affecting calves' health and welfare [already extensively listed in the 1995 report of the Scientific Veterinary Committee Animal Welfare section (SVC, 1995), are updated and subsequently to systematically determine whether these factors constitute a potential hazard or risk. To the latter end their severity and likelihood of occurrence in animal (sub) populations were evaluated and associated risks to calf welfare estimated, hence providing the basis for risk managers to decide which measures could be contemplated to reduce or eliminate such risks. It should be noted, however, that this does not imply that a hazard that has a serious effect on just a few animals should not be dealt with by managers on farm level as the suffering imposed on some animals constitute a major welfare problem for those individuals.

3.2. The chosen approach

In line with the terms of reference the working group restricted itself to (in essence qualitative) risk assessment, i.e. only one of three elements essential to risk analysis
A risk assessment approach was followed, similar to the one generally adopted when assessing microbiological risks, i.e. along the lines suggested at the 22nd session of the Codex Alimentarius Commission (CAC, 2002). Incidentally, these guidelines have been characterized by the CAC as 'interim' because they are subject to modifications in the light of developments in the science of risk analysis and as a result of efforts to harmonize definitions across various disciplines. CAC's guidelines are in essence exclusively formulated for the purpose of assessing risks related to microbiological, chemical or physical agents of serious concern to public health.

Consequently - considering their disciplinary focus - the working group had to adapt the CAC definitions to serve their purpose. These adapted definitions, have, in alphabethical order, been included in Chapter 2 (see Risk Analysis Terminology)

The objectives of this report 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.

Where relevant, food safety implications of different farming systems are also considered.

The report is structured in five major parts. The first three follow the Scientific Veterinary Committee’s previous report “On the welfare of calves” with introductory chapters 4-7 on background, measurements and needs in relation to calf welfare, chapter 8 describing housing, diet and management and chapter

9 describing comparison of systems and factors. In chapter 10 common disease and use of antibiotics is described. The other two parts involve aspects of meat quality and food safety (chapter 11) and the risk assessment (chapters 12). Conclusions and recommendations from the previous SVC document together with updated conclusions derived from recent research findings are presented in chapter 13.

3.3. Effect of transport and slaughter on calves' health and welfare

Although it is agreed that welfare and health of calves can be substantially affected in the course of and as a result of transport, this report does not consider animal health and welfare aspects of calves during transport because there is already a comprehensive recent report of the Scientific Committee on Animal Health and Animal Welfare (SCAHAW), on "The welfare of animals during transport (details for horses, pigs, sheep and cattle)" which was adopted on 11 March 2002 (DG SANCO, 2002). The report takes into account all aspects related with transport that could affect the health and welfare of cattle and calves, including the direct effects of transport on the animals and the effects of transport on disease transmission. The loading methods and handling facilities for cattle, the floor space allowance, the relationships of stocking and the density requirements, the vehicle design, space requirements and ventilation for cattle transporters (see also the AHAW Scientific Opinion related to Standards for the microclimate inside animal road transport vehicles, EFSA-Q-2003-085), the behaviour of cattle during road transport, the road conditions, long distance transport and the travel times are also reviewed. Recommendations for all these aspects are also given in that report.

4. Comparison of systems and factors

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

4.1.1. Feeding systems and weaning strategies

<u>Recommendations</u>

Without a fully functional rumen, calves will be unable to utilise nutrients provided in the post-weaning dry feed diet. Attention must paid to type of forage and consistent of particle size of starter grain in order to achieve a proper rumen development. 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. A calf consuming 0.7 kg of dry feed or more on three consecutive days is ready for weaning. 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.

4.1.2. Quality of solid and liquid feed

Conclusions

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. Although some solid feeds may exacerbate problems with abomasal ulcers in milk-fed veal calves, properly balanced rations seem to moderate this effect.

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.

If vegetable proteins are not properly treated, milk replacers may cause hypersensitivity reactions in the gut, which may compromise calf welfare.

Recommendations

It is recommended that solid feeds provided to veal calves, in addition to milk replacer, are adequately balanced in terms of 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.

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.

4.1.3. Dietary iron and anaemia

Conclusions

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}.

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, for example, when the calves are brought into a unit, between 12-14 weeks of fattening, and during the last four weeks before slaughter.

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.

Recommendations

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 which cause anaemia but which are not related to diet.

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.
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.
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.

4.2. Space and pen design

Recommendations

Space should be enough to allow animals to fulfill their needs for social behaviour, lying and grooming.

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.

4.3. Flooring and bedding material

Recommendations

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.

4.4. Degree of social contact

Conclusions

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.

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:

1. Especially when individuals are provided with inadequate access to teats and roughage in the diet, cross-sucking and other abnormal sucking behaviour may occur.
2. 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.
3. 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.

Recommendations

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.

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.

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.

4.5. Temperature, ventilation and air hygiene

Conclusions

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.

These effluents can have distinct impacts on air, water, soil, biodiversity in plants, forest decay and also on animals and including humans.

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.

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.

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.

Ventilation plays a decisive role in reducing the incidence of respiratory disease. Temperatures below 5 °C can compromise lung function.

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.

Air velocities close to the animals of more than 0.5 m/s can significantly increase respiratory sounds in calves.

Sufficient air space in confined buildings can help to reduce the concentration of airborne bacteria.

Calf houses contain relatively high amounts of endotoxins (640 EU) (EU: Endotoxin Unit, see Scientific Report, www.efsa.eu.int)

There is concern that antibiotic residues may contribute to the development of bacterial resistance.

Local and regional environmental problems are enhanced by high animal densities and insufficient distances between farms and residential areas.

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.

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.

<u>Recommendations</u>

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.

Adequate and efficient feeding regimes are required with minimal wastage of nitrogen and phosphorous and limited use of growth promoters and drugs.

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.

Temperatures for young calves should range between 5 and 26 °C.

Ammonia concentrations should be kept as low as possible preferably not more than 6 ppm.

Housing and management should aim a reducing dust, bacteria and endotoxin concentrations in the animal house air.

Minimum ventilation rates of 10 m^3 per 100 kg live weight should be applied.

4.6. Human-animal relationships

Recommendation

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.

4.7. Dehorning and castration

Recommendations

If cattle are to be dehorned, it is recommend to disbud young cattle rather than to dehorn older ones. Disbudding by cautery is recommended over other methods. Local anaesthesia (e.g. 5-6 mL lidocaïne or lignocaïne 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.

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).

5. Calf diseases and use of antibiotics

Conclusions

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.

6. Food safety aspects of calf farming

<u>Conclusions and recommendations</u>

Main foodborne hazards associated with calf farming are *Salmonella* spp., human pathogenic-verotoxigenic *Escherichia coli* (HP-VTEC), thermophilic *Campylobacter* spp., *Mycobacterium bovis*, *Taenia saginata cysticercus* and *Cryptosporidium parvum/Giardia duodenalis.*

The prevalence-level of infection and/or contamination of calves with, and further spread of, foodborne pathogens on farms depend on the status and the inter-relationship of different contributing factors that are inherently highly variable.

Present knowledge and published data are insufficient to produce a universal risk assessment enabling quantitative food safety categorization/ranking of different types of calf farming systems.

Nevertheless, generic principles for risk reductions for the main foodborne pathogens at calf farm level are known and are based on the implementation of effective farm management (e.g. QA, husbandry, herd health plans, biosecurity) and hygiene measures based on GFP-GHP.

Recommendations for future research

For quantitative food safety risk categorization of farming systems individually, and/or their related ranking, further scientific information is needed. Accordingly, related research should be encouraged.

7. Overall conclusions and recommendations

The conclusions of the Scientific Veterinary Committee report on the Welfare of Calves are presented in Table 1 below together with additions relevant in the light of this update of the SVC report.

Table 1. Conclusions and recommendations on calf welfare

	1995 Report (conclusions marked C, recommendations marked R)	EFSA Opinion (conclusions and recommendations)
	GENERAL MANAGEMENT	
1	Housing and management systems for calves should be designed so that the needs of the animals are satisfied and the welfare of the animals is good.**R**	Agreed
2	Methods of assessing the welfare of calves, including physiological, behavioural, health and growth measures, have been developed and used in a wide range of scientific studies.**C**	Agreed
3	A variety of housing and management methods for the calves intended as dairy herd replacers, beef animals and veal animals are in use and these methods vary in their effects on calf welfare.**C**	Agreed
4	The best conditions for young rearing calves involve leaving the calf with the mother in a circumstance where the calf can suckle and can subsequently graze and interact with other calves.**C**	Agreed
5	Where the calf will be separated from its mother at an early age, evidence suggests that it is normally beneficial for the calf if the mother is allowed to lick the calf thoroughly for a few hours after birth.**C**	Agreed **R** Whenever possible, cows should be given the opportunity to lick the calf during at least three hours after parturition.
6	It is important that the calf should receive sufficient colostrum within the first six hours of life and as soon as possible after birth, in conditions which facilitate antibody absorption, preferably by suckling from the mother, so as to ensure adequate immunoglobulin levels in the blood. **R** Where necessary, suckling assistance or additional colostrum should be provided for calves left to suckle from the dam.**R**	Agreed Agreed
7	Calves need resources and stimuli which are normally provided by their mothers. All calves should be given adequate food and water, appropriate conditions of temperature and humidity, adequate opportunities to exercise, good lying conditions, appropriate stimuli for sucking during the first few weeks of life and social contacts with other calves from one week of age onwards. Specific aspects of housing and management which fulfill these conditions are detailed.	Agreed

8	Young calves reared without their mothers should receive considerate human contact, preferably from the same stockperson throughout the growing period.**R**	*Man-animal relationships:* Agreed Stockpersons should be appropriately trained so that they have sufficient skill in the rearing of calves. They should have positive attitudes towards animals and to working with them in order to handle them while minimising stress and to maintain a high quality of health control. Rough contacts (e.g. use of a painful device such as an electric prod, or loud noises) should be avoided and gentle contacts (e.g. talking softly, petting, offering food) should be encouraged. These contacts are of particular importance for calves in groups or with their dam that may tend not to approach humans easily.
	HOUSING	
9	Where calves cannot be kept with their mother, the system where welfare is best is in groups with a bedded area and an adequate space allowance available to them.**C**	Agreed. **R** See 13 below.
10	The welfare of calves is very poor when they are kept in small individual pens with insufficient room for comfortable lying, no direct social contact and no bedding or other material to manipulate. **C**	Agreed **R** As the floor affects the resting and lying posture of calves they should be useful to have a comfortable floor. Wet floors should be avoided due to thermal and resting problems.
11	Tethering always causes problems for calves. Calves housed in groups should not be tethered <u>except for periods of not more than one hour</u> at the time of the feeding of milk or milk substitute. Individually housed calves should not be tethered. **R**	Agreed
12	Calves are vulnerable to respiratory and gastro-intestinal disease and welfare is poor in diseased animals. Better husbandry is needed to minimize disease in group housing conditions but results that are as good as those from individual housing can be obtained. **C**	Agreed **R** Groups with calves of different ages should be kept small.
13	Calves are very social animals, interacting frequently with other calves after one week of age and developing normal social behaviour only if they can interact freely with other calves. Individual pens which have open sides allow some social contact with neighbouring calves. However group housing allows a better, more complex social life. **C**	13 Agreed. 14 Agreed. 15 Agreed except for advice below about separation to be allowed for first two weeks if inter-sucking is expected*:* *C* Group housing can help calves to acquire social skills. Some experience of mixing is of particular importance since calves that have been reared for a while in a group dominate calves that have always been in individual crates .

<table>
<tr><td>14</td><td>Every calf should be able to groom itself properly, turn around, stand up and lie down normally and lie with its legs stretched out if it wishes to do so. R</td><td rowspan="2">R 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.
C 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:
- Especially when individuals are provided with inadequate access to teats and roughage in the diet, cross-sucking and other abnormal sucking behaviour may occur.
- 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.
- 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.
R 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 a quarantine situation should be used in order to reduce disease in the calves and hence prevent poor welfare.</td></tr>
<tr><td>15</td><td>In order to provide an environment which is adequate for exercise ,exploration and free social interaction, calves should be kept in groups. Calves should never be kept at too high stocking density. The following requirements are based on evidence of increasingly poor welfare as space allowance decreases. The space allowance should provide, especially for allowing resting postures, an area for each calf of at least (its height at the withers) x (its body length from the tip to its nose when standing normally to the caudal edge of the tuber ischii or pin bone x 1.1). The length measurements takes account of the forward and backward movements involved in standing up and lying down. This calculation takes account of differences in size amog breeds and with age. As a guideline, for holstein calves this area is 1.4 m^2 at 8 weeks, 1.8 m^2 at 16 weeks and 2.1 m2 at 22 weeks. R</td></tr>
<tr><td>16</td><td>For a given space allowance per calf, increasing group size results in a larger total area and hence better possibilities for exercise, social interaction and improved environmental complexity. C
Larger groups are preferred because of the better possibilities for providing an adequate environment but there are limits to the numbers of animals which should be in one building section and risks associated with mixing of calves from different sources should be considered. R</td><td>Agreed
R The space provided for calves should be enough to allow animals to fulfill their needs for social behaviour, lying and grooming. Space allowance per animal should be greater for groups of 2 – 5 animals and for feeding systems, and pen shapes or flooring materials that necessitate extra space availability.</td></tr>
<tr><td>17</td><td>If the preferred system, group housing, is not possible then individual pens whose width is at least the height of the calf at the withers and whose length is at least the length of the calf from the tip of its nose when standing normally to the caudal edge of the tuber ischii or pin bone x 1.1 should be used. This space requirement is calculated on the basis of the space required for normal</td><td>Agreed
R As the pen shape affects the use of space by animals, pens should maximize the perimeter and pen space should be divided into different usable areas.</td></tr>
</table>

	movements and evidence of increasingly poor welfare **R**	
18	Appropriate bedding for example straw is recommended. Bedding must be changed at appropriate intervals and every calf should have access to a dry lying area. Slatted floors must not be slippery and must not be a cause of tail tip necrosis. **R**	Agreed See 10 above
19	Buildings should be adequately ventilated taking into account of the number of animals present and the external conditions. The air space in the building should be $6m^3$ per calf up to 6 weeks of age and an amount of air space which increases with age is needed for older calves.**R**	Agreed **C** - Calf rearing causes significant emissions such as nitrate, phosphate, heavy metals and possibly antibiotics in manure and liquid effluents as well as odour, gases, dusts, micro-organisms and endotoxins in the exhaust air from animal houses, from manure storage facilities, during application of manure and during grazing. - These effluents can have distinct impacts on air, water, soil, and thus also on animals. - 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. - Respiratory disorders are the second largest reason for morbidity and mortality in calf rearing. The most important reason are environmental conditions such as hygiene, management and the physical, chemical and biological factors of the aerial environment. - Ventilation plays a decicive role in reducing the incidence of respiratory diseases. Temperatures below 5 C can compromise lung function. - Ammonia concentrations of more than 6 ppm seem to increase respiratory affections. Relative humidity of more than 80 % bear the risk of increased heat dissipation and can help bacteria to survive in airborne state. - Air velocities close to the animals of more than 0.5 m/s can increase respiratory sounds in calves significantly. - Sufficient air space in confined buildings can help to reduce the concentration of airborne bacteria. - Calf houses contain relatively high amounts of endotoxins. - There is concern that antibiotic residues may contribute to the development of bacterial resistance. - Environmental problems in calf houses are enhanced by high animal densities,

		insufficient distances between farms. - When housing systems are compared, although dust emission levels will seldom pose problems for the health of calves, ammonia emission levels may be higher enough to exacerbate calf disease, especially in slatted floor units. R - 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. - Adequate and efficient feeding regimes are required with minimal wastage of nitrogen and phosphorous and limited use of growth promoters and drugs. - There is an urgent need for cooperative research to design appropriate ventilation systems to improve health and welfare of calves kept in confind rearing conditions. - Temperatures for young calves should range between 5 and 26 C. - Ammonia concentrations should be kept as low as possible, preferably not more than 6 ppm. - Housing design and management procedures should aim to reduce dust, bacteria and endotoxin concentrations in the animal house air. - Minimum ventilation rates of 10 c^3 per 100 kg live weight should be applied.
	FOOD AND WATER	
20	Calves which lack specific nutrients, including iron, which are given poorly balanced diet, and which are not provided with adequate roughage in the diet after four weeks of age can have serious health problems, can show serious abnormalities of behaviour, and can have substantial abnormalities in gut development. C Every calf should receive a properly balanced diet with adequate nutrients.R	Agreed R It is recommended that solids feeds provided to veal calves, in addition to milk replacer, are adequately balanced in terms of 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. C 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 the 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. Hence it is normal practice to identify young veal production calves with less than 6.0 mmol l^{-1} haemoglobin in plasma and to provide supplementary iron in addition to that normally included in the diet. For older calves, including those in the last four weeks before slaughter, efficient production is possible in individual calves whose haemoglobin concentration is above 4.5mmol l^{-1}. 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 very low iron content. Anaemia can be identified and quantified adequately if checks are carried out on veal production calves of 2-4 weeks, for example, when the calves are brought into a unit, between 12-14 weeks of fattening, and during the last four weeks before slaughter. If the concentration of haemoglobin in the blood of a group 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. R 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 6.0mmol 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 4.5mmol 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 which cause anaemia but which are not related to diet, R 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. 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.
21	Some non-milk proteins are inappropriate for use in a milk substitute fed to calves because they produce allergenic reactions. Some carbohydrates cannot be easily or properly digested by calves and they may cause digestive upset. No milk substitute should be fed to calves unless it can be easily digested and does not cause harmful reactions in the calves. **R**	Agreed
22	Acidification of milk can reduce the incidence of diarrhoea, but any forms of acidified milk which are unpalatable to calves or which harm the calves should not be used. **R**	Agreed
23	Every calf should be fed fermentable material, appropriate in quality and sufficient in quantity to maintain the microbial flora of the gut and sufficient fibre to stimulate the development of villi in the rumen. Roughage, in which half of the fibre should be at least 10 mm in length, should be fed to calves. They should receive a minimum of 100 g of roughage per day from 2 to15 weeks of age, increasing to 250 g per day from 15 to 26 weeks of age but it would be better if these amounts would be doubled. The development of the rumen should be checked by investigating villi development in a proportion of calf guts after slaughter. **R**	Agreed **R** Without a fully functional rumen, calves will be unable to utilise nutrients provided in the post-weaning dry feed diet. Attention should paid to type of forage and consistent of particle size of starter grain in order to achieve a proper rumen development. 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. A calf consuming 0.7 kg of dry feed or more on three consecutive days is ready for weaning. 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.
24	There are clear signs of increased disease susceptibility and immunosuppression in calves up to 13 weeks of age, whose blood haemoglobin concentration is below 4.5 mmol/liter. However, in some studies the antibiotic treatment was not higher in calves whose haemoglobin was near to 4mmol/litre than in calves whose level was near to 5mmol/litreat 20 weeks of age. Studies of exercise in anaemic calves show that there can be problems during exercise at a level of 5,5 mmol/litre. C All calves should be fed in such a	Agreed see 23

	way that their haemoglobin level does not fall below a minimum of 4.5 mmol/litre. **R**	
25	Where calves are fed a diet which is lower in iron than 50mg/kg, an adequate sample of animals should be checked at 12 and 24 weeks of age in order to find out whether the blood haemoglobin concentration is too low. **R**	Agreed see 23
26	Young calves have a very strong preference to suck a teat or teat-like object. It is preferable for calves to be fed milk or milk substitute from a teat during the first four weeks of life. Calf welfare is improved if a non-nutritive teat is provided during the first four weeks of life especially if they are not fed from a teat. **C**	Agreed
27	When young group-housed calves are fed milk or milk substitute, the social facilitation effects of having a group of teats close together are beneficial. It is also advisable for several teats to be provided in groups of older calves. Transponder controlled feeder systems have been found to work well. **C**	Agreed
28	The feeding to calves of large quantities of milk or milk substitute in a single daily meal can cause digestive problems. Hence when calves are fed more than 10% of body weight in milk or milk substitute each day, this should be fed in at least two meals per day. **R**	Agreed
29	Calves fed *ad libitum,* or close to this level should not be weaned off milk or milk replacer until they are consuming a minimum of 750 g of concentrates per head per day in the week prior to weaning. Where calves are fed restricted quantities of milk or milk replacer before weaning they should not be weaned until they are consuming a minimum of 1000 g of concentrates per head per day in the week prior to weaning. **R**	Agreed
30	Calves which are diseased and calves which are in hot conditions often need to drink water as well as milk or milk substitute and all calves drink water if it is available. The provision of milk or milk substitute is not an adequate alternative for provision of water. Hence calves should be provided daily with water to drink. It is recommended that drinkers be provided in all pens. **R**	Agreed
		R 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 early reaction of all signs of any beginning diseases.
DEHORNING AND CASTRATION		
	Dehorning calves between 1 – 3 weeks by cauterisation with adequate anaesthesia and analgesia (no precision given) Castrate calves at 3 months with adequate anaesthesia and analgesia (no precision given)	**R** Dehorning: if cattle are to be dehorned, it is recommended to disbud young cattle rather than to dehorn older ones. Disbudding by cauterisation is recommended over other methods. Local anaesthesia (e.g. 5-6 mL lidocaïne or lignocaïne 2% around the corneal nerve) and analgesia with a non steroidal anti-inflammatory drug (5 mL Flunixin meglumine or 3 – 3.75 mg ketoprofen 10% / kg body weight) shall be performed 15-20 min before disbudding. **R** Castration: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).
CONCLUSIONS ON FOOD SAFETY ASPECTS		
		- Main foodborne hazards associated with calf farming are *Salmonella* spp., human pathogenic-verotoxigenic *Escherichia coli* (HP-VTEC), thermophilic *Campylobacter* spp., *Mycobacterium bovis*, *Taenia saginata cysticercus* and *Cryptosporidium parvum/Giardia duodenalis.* - The prevalence-level of infection and/or contamination of calves with, and further spread of, foodborne pathogens on farms depend on the status and the inter-relationship of different contributing factors that are inherently highly variable. - Present knowledge and published data are insufficient to produce a universal risk assessment enabling quantitative food safety categorization/ranking of different types of calf farming systems. - Nevertheless, generic principles for risk reductions for the main foodborne

		pathogens at calf farm level are known and are based on the implementation of effective farm management (e.g. QA, husbandry, herd health plans, biosecurity) and hygiene measures based on GFP-GHP
RECOMMENDATIONS FOR FUTURE RESEARCH		
	.	It is recommended that future research should be conducted within the following areas: - Hemoglobin levels and iron deficiences of veal calves aged 12-24 weeks. - The monitoring of haemoglobin in groups of calves using representative samples - Exposure to allergenic proteins - Solid and liquid food balance. Exposure to too rich diets and changes in feed composition. - Space requirements - Health monitoring systems and the effect of such on clinical health in calves - Infection transmission (respiratory and digestive diseases) due to direct contact between calves in relation to social benefits of mixing - Pain relief when disbudding, dehorning and castrating calves -Design of appropriate ventilation systems for calves in confined rearing conditions - Health and environmental effects of feeding minerals as antimicrobial agents - For quantitative food safety risk categorization of farming systems individually, and/or their related ranking, further scientific information is needed. Accordingly, related research should be encouraged.

8. References

References used in this Scientific Opinion are available and listed in the Scientific Report published at the EFSA web (www.efsa.eu.int).

9. Working Group Members and Acknowledgements

The AHAW Panel wishes to thank the members of the working group chaired by panel member Bo Algers: D. M. Broom, E. Canali, J. Hartung, F. J. M. Smulders, K. van Reenen, I. Veissier, for the preparation of the Scientific Report, which has been used as the basis of this Scientific Opinion.

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Chapter 11 of the Scientific Report was adopted by the BIOHAZ Panel with the following Panel Members: Herbert Budka, Sava Buncic, Pierre Colin, John D Collins, Christian Ducrot, James Hope, Mac Johnston, Günter Klein, Hilde Kruse, Ernst Lücker, Simone Magnino, Riitta Liisa Maijala, Antonio Martínez López, Christophe Nguyen-The, Birgit Noerrung, Servé Notermans, George-John E Nychas, Maurice Pensaert, Terence Roberts, Ivar Vågsholm, Emmanuel Vanopdenbosch.

The Scientific Panel on Biological Hazards wishes to acknowledge the contribution of the working group that prepared the draft opinion: Sava Buncic, Frans Smulders and John D. Collins.

10. AHAW Scientific Panel Members

The Scientific AHAW Panel adopted the current Scientific Opinion by written procedure on May 24, 2006. Members of the AHAW Panel are:

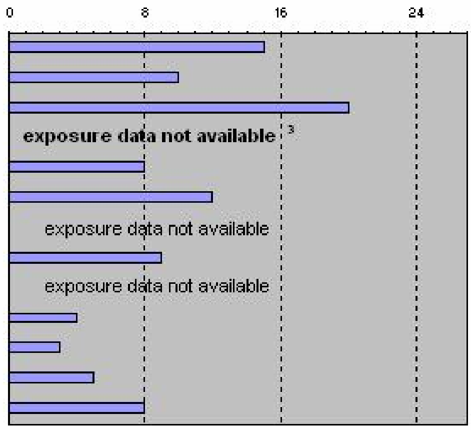
Bo Algers, Harry J. Blokhuis, Donald M. Broom, Ilaria Capua, Stefano Cinotti, Michael Gunn, Jörg Hartung, Per Have, Xavier Manteca Vilanova, David B. Morton, Michel Pépin, Dirk U. Pfeiffer, Ronald J. Roberts, José Manuel Sánchez Vizcaino, Alejandro Schudel, J. Michael Sharp, Georgios Theodoropoulos, Philippe Vannier, Marina Verga, Martin Wierup, Marion Wooldridge.

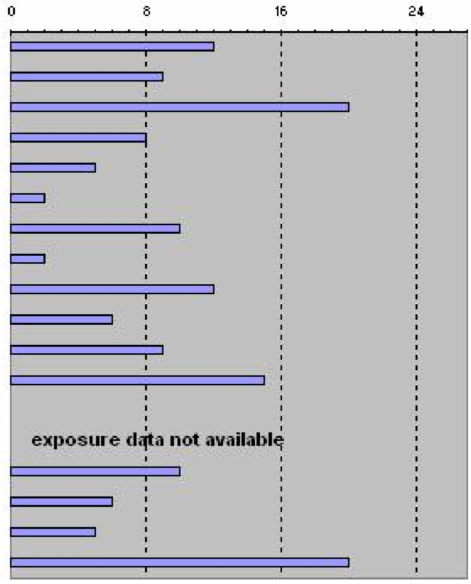
11. Annex 1. Risk characterization scores

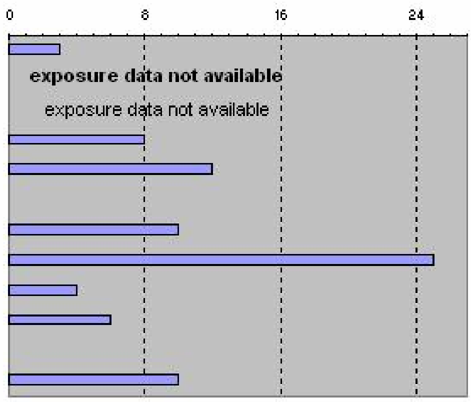
Assessment of risks to welfare of intensively reared calves; subcategory A.a.:

Aa: WHITE VEAL IN SMALL GROUPS, NOT SUCKLING

Associated with		Hazards identified	HC[1]	EA[2]	Risk characterization score (HC x EA)
NUTRITION	◐	Inadequate colostrum intake - quantity	5	3	
	◐	Inadequate colostrum intake - quality	5	2	
	●	Inadequate colostrum intake - duration	5	4	
	?	Iron deficiency (Hb below 4.5 mmol/l)	5		**exposure data not available** [3]
	○	Deficiency of other minerals (Cu, Se)	4	2	
	◐	Insufficient access to water (not milk)	4	3	
	?	Allergenic proteins	3		exposure data not available
	◐	Inappropriately balanced solid food	3	3	
	?	Too rich diet (overfeeding)	3		exposure data not available
	○	Underfeeding	4	1	
	○	Too low temperature of milk / -replacer	3	1	
	○	Exposure to contaminated feed	5	1	
	○	No access to natural of artificial teat	2	4	
HOUSING			HC	EA	
	◐	High humidity	4	3	
	◐	Indoor draughts	3	3	
	●	Inadequate ventilation	5	4	
	○	Poor air quality (amm., bio-aer., dust)	4	2	
	○	Poor air quality (H2S)	5	1	
	○	Poor insulation against cold	2	1	
	◐	Poor floor conditions, gaps too large	5	2	
	○	Poor floor conditions, too abrasive	2	1	
	◐	Poor floor conditions, too slippery	4	3	
	○	Poor floor conditions, too dirty	2	3	
	◐	Poor floor conditions, wet floor for lying	3	3	
	◐	No bedding	3	5	
	?	Insufficient floor space allowance	5		**exposure data not available**
	○	Insufficient light	5	2	
	○	Barren environment	2	3	
	○	Social isolation	5	1	
	●	Exposure to pathogens	5	4	
MANAGEMENT			HC	EA	
	○	Rough handling on the farm	3	1	
	?	Inadequate health monitoring	4		**exposure data not available**
	?	Inadequate haemoglobin monitoring	3		exposure data not available
	○	Continuous restocking (no all-in/out)	4	2	
	◐	Poor response to health problems	4	3	
	○	Withholding necessary veterinary care	5		
	◐	Lack of maternal care	2	5	
	●	Mixing calves from different sources	5	5	
	○	Insufficient contact with humans	2	2	
	○	Poorly educated stockperson	3	2	
	◐	Separation from the dam	2	5	







[1] HC = Hazard Characterization

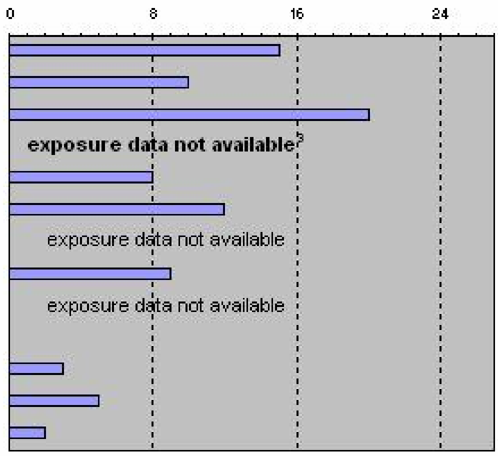
[2] EA = Exposure Assessment

[3] Risk characterization uncertain due to lack of data on exposure. Where indicated in bold, hazards were characterized as moderately to very serious.

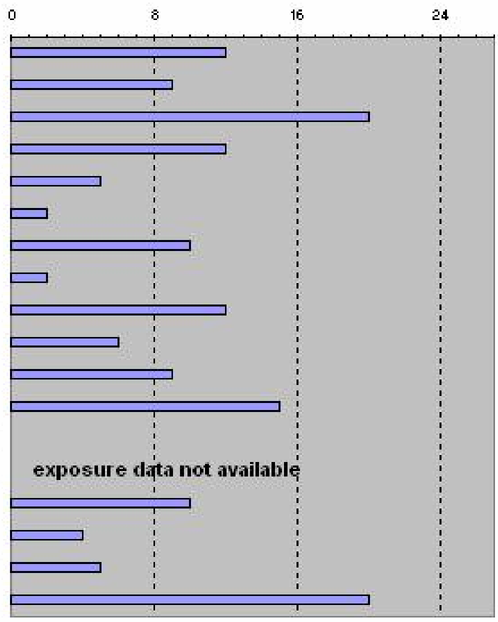
Assessment of risks to welfare of intensively reared calves; subcategory A.b.:

Ab: WHITE VEAL IN LARGER GROUPS, WITH AUTOMATIC FEEDING

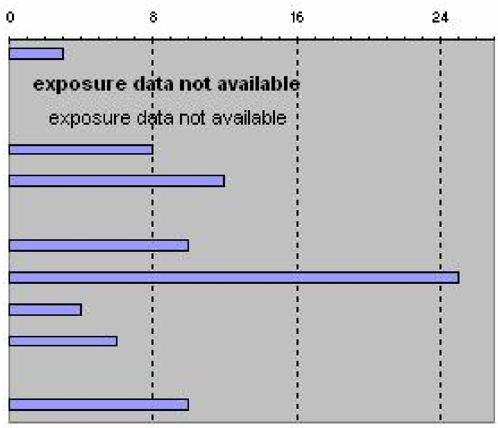
Associated with		Hazards identified	HC[1]	EA[2]	Risk characterization score (HC x EA)
NUTRITION	◒	Inadequate colostrum intake - quantity	5	3	
	◒	Inadequate colostrum intake - quality	5	2	
	●	**Inadequate colostrum intake - duration**	5	4	
	?	Iron deficiency (Hb below 4.5 mmol/l)	5		**exposure data not available[3]**
	○	Deficiency of other minerals (Cu, Se)	4	2	
	◒	Insufficient access to water (not milk)	4	3	
	?	Allergenic proteins	3		exposure data not available
	◒	Inappropriately balanced solid food	3	3	
	?	Too rich diet (overfeeding)	3		exposure data not available
	○	Underfeeding	4	2	
	○	Too low temperature of milk / -replacer	3	1	
	○	Exposure to contaminated feed	5	1	
	○	No access to natural of artificial teat	2	1	



Associated with		Hazards identified	HC	EA	Risk characterization score (HC x EA)
HOUSING	◒	High humidity	4	3	
	◒	Indoor draughts	3	3	
	●	**Inadequate ventilation**	5	4	
	◒	Poor air quality (amm., bio-aer., dust)	4	3	
	○	Poor air quality (H2S)	5	1	
	○	Poor insulation against cold	2	1	
	◒	Poor floor conditions, gaps too large	5	2	
	○	Poor floor conditions, too abrasive	2	1	
	◒	Poor floor conditions, too slippery	4	3	
	○	Poor floor conditions, too dirty	2	3	
	◒	Poor floor conditions, wet floor for lying	3	3	
	◒	No bedding	3	5	
	?	Insufficient floor space allowance	5		**exposure data not available**
	◒	Insufficient light	5	2	
	○	Barren environment	2	2	
	○	Social isolation	5	1	
	●	**Exposure to pathogens**	5	4	



Associated with		Hazards identified	HC	EA	Risk characterization score (HC x EA)
MANAGEMENT	○	Rough handling on the farm	3	1	
	?	Inadequate health monitoring	4		**exposure data not available**
	?	Inadequate haemoglobin monitoring	3		exposure data not available
	○	Continuous restocking (no all-in/out)	4	2	
	◒	Poor response to health problems	4	3	
	○	Withholding necessary veterinary care	5		
	◒	Lack of maternal care	2	5	
	●	**Mixing calves from different sources**	5	5	
	○	Insufficient contact with humans	2	2	
	○	Poorly educated stockperson	3	2	
	◒	Separation from the dam	2	5	



[1] HC = Hazard Characterization

[2] EA = Exposure Assessment

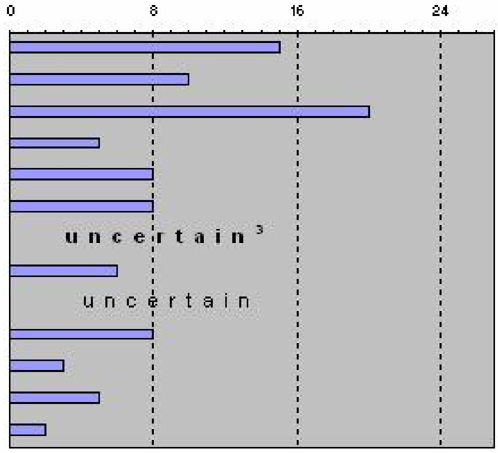
[3] Risk characterization uncertain due to lack of data on exposure.

Where indicated in bold, hazards were characterized as moderately to very serious.

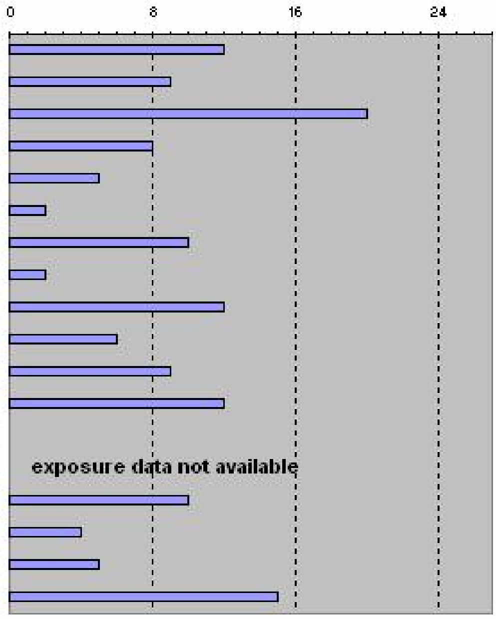
		Assessment of risks to welfare of intensively reared calves; subcategory A.c.:		
		Ac: PINK VEAL IN SMALL GROUPS		

Risk characterization score (HC x EA)

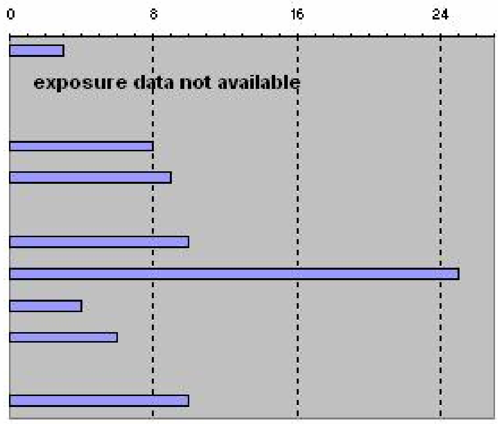
Associated with		**Hazards identified**	HC[1]	EA[2]
NUTRITION	◍	Inadequate colostrum intake - quantity	5	3
	◍	Inadequate colostrum intake - quality	5	2
	●	Inadequate colostrum intake - duration	5	4
	○	Iron deficiency (Hb below 4.5 mmol/l)	5	1
	○	Deficiency of other minerals (Cu, Se)	4	2
	○	Insufficient access to water (not milk)	4	2
	?	Allergenic proteins	3	
	○	Inappropriately balanced solid food	3	2
	?	Too rich diet (overfeeding)	3	
	○	Underfeeding	4	2
	○	Too low temperature of milk / -replacer	3	1
	○	Exposure to contaminated feed	5	1
	○	No access to natural of artificial teat	2	1



Associated with		Hazards identified	HC	EA
HOUSING	◍	High humidity	4	3
	◍	Indoor draughts	3	3
	●	Inadequate ventilation	5	4
	○	Poor air quality (amm., bio-aer., dust)	4	2
	○	Poor air quality (H2S)	5	1
	○	Poor insulation against cold	2	1
	◍	Poor floor conditions, gaps too large	5	2
	○	Poor floor conditions, too abrasive	2	1
	◍	Poor floor conditions, too slippery	4	3
	○	Poor floor conditions, too dirty	2	3
	◍	Poor floor conditions, wet floor for lying	3	3
	◍	No bedding	3	4
	?	Insufficient floor space allowance	5	
	◍	Insufficient light	5	2
	○	Barren environment	2	2
	○	Social isolation	5	1
	◍	Exposure to pathogens	5	3



Associated with		Hazards identified	HC	EA
MANAGEMENT	○	Rough handling on the farm	3	1
	?	Inadequate health monitoring	4	
	○	Continuous restocking (no all-in/out)	4	2
	◍	Poor response to health problems	3	3
	○	Withholding necessary veterinary care	5	
	◍	Lack of maternal care	2	5
	●	Mixing calves from different sources	5	5
	○	Insufficient contact with humans	2	2
	○	Poorly educated stockperson	3	2
	◍	Separation from the dam	2	5



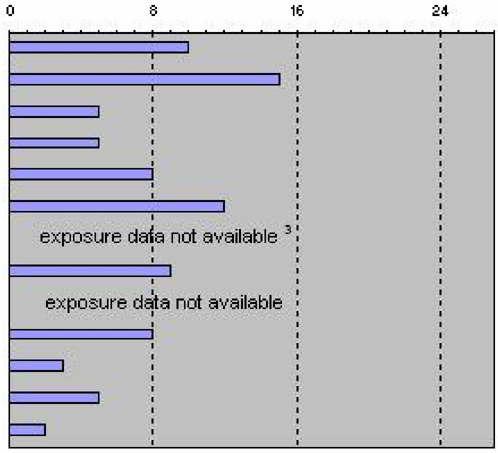
[1] HC = Hazard Characterization
[2] EA = Exposure Assessment
[3] Risk characterization uncertain due to lack of data on exposure.
Where indicated in bold, hazards were characterized as moderately to very serious.

Assessment of risks to welfare of intensively reared calves; subcategory A.d.:

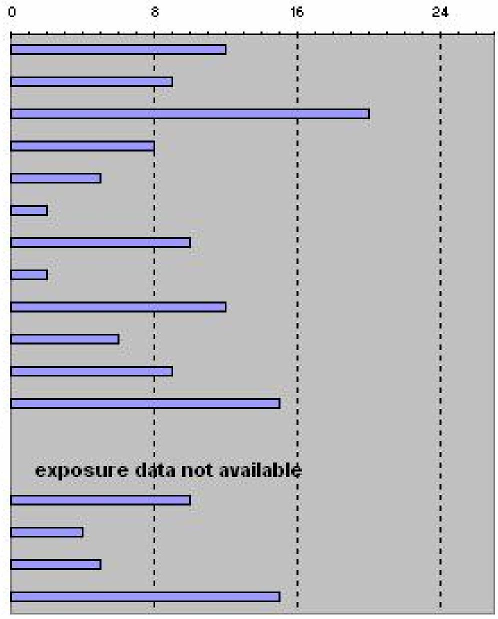
Ad: WHITE VEAL IN SMALL GROUPS, SUCKLING

Risk characterization score (HC x EA)

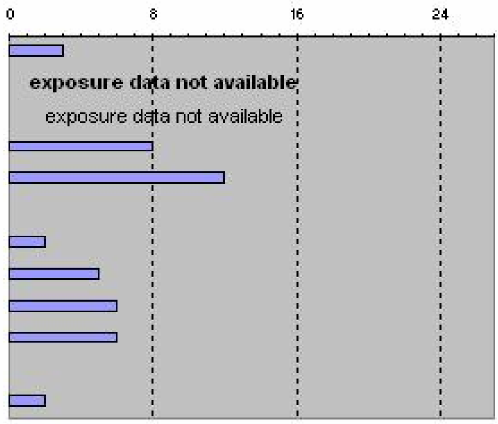
Associated with		**Hazards identified**	HC[1]	EA[2]	Risk characterization score (HC x EA)
NUTRITION	◍	Inadequate colostrum intake - quantity	5	2	
	◍	Inadequate colostrum intake - quality	5	3	
	○	Inadequate colostrum intake - duration	5	1	
	○	Iron deficiency (Hb below 4.5 mmol/l)	5	1	
	○	Deficiency of other minerals (Cu, Se)	4	2	
	◍	Insufficient access to water (not milk)	4	3	
	?	Allergenic proteins	3		exposure data not available [3]
	◍	Inappropriately balanced solid food	3	3	
	?	Too rich diet (overfeeding)	3		exposure data not available
	○	Underfeeding	4	2	
	○	Too low temperature of milk / -replacer	3	1	
	○	Exposure to contaminated feed	5	1	
	○	No access to natural of artificial teat	2	1	



Associated with		Hazards identified	HC	EA	Risk characterization score (HC x EA)
HOUSING	◍	High humidity	4	3	
	◍	Indoor draughts	3	3	
	●	Inadequate ventilation	5	4	
	○	Poor air quality (amm., bio-aer., dust)	4	2	
	○	Poor air quality (H2S)	5	1	
	○	Poor insulation against cold	2	1	
	◍	Poor floor conditions, gaps too large	5	2	
	○	Poor floor conditions, too abrasive	2	1	
	◍	Poor floor conditions, too slippery	4	3	
	○	Poor floor conditions, too dirty	2	3	
	◍	Poor floor conditions, wet floor for lying	3	3	
	◍	No bedding	3	5	
	?	Insufficient floor space allowance	5		**exposure data not available**
	◍	Insufficient light	5	2	
	○	Barren environment	2	2	
	○	Social isolation	5	1	
	◍	Exposure to pathogens	5	3	



Associated with		Hazards identified	HC	EA	Risk characterization score (HC x EA)
MANAGEMENT	○	Rough handling on the farm	3	1	
	?	Inadequate health monitoring	4		**exposure data not available**
	?	Inadequate haemoglobin monitoring	3		exposure data not available
	○	Continuous restocking (no all-in/out)	4	2	
	◍	Poor response to health problems	4	3	
	○	Withholding necessary veterinary care	5		
	○	Lack of maternal care	2	1	
	○	Mixing calves from different sources	5	1	
	○	Insufficient contact with humans	2	3	
	○	Poorly educated stockperson	3	2	
	○	Separation from the dam	2	1	

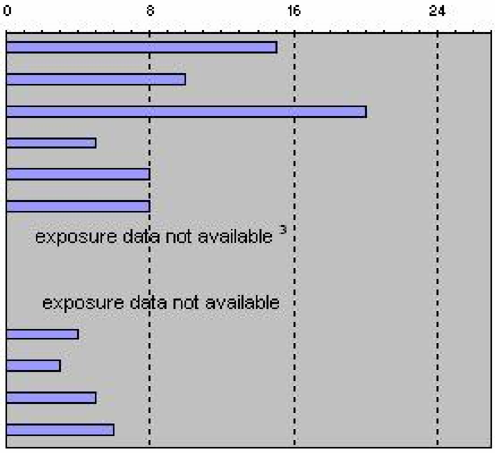


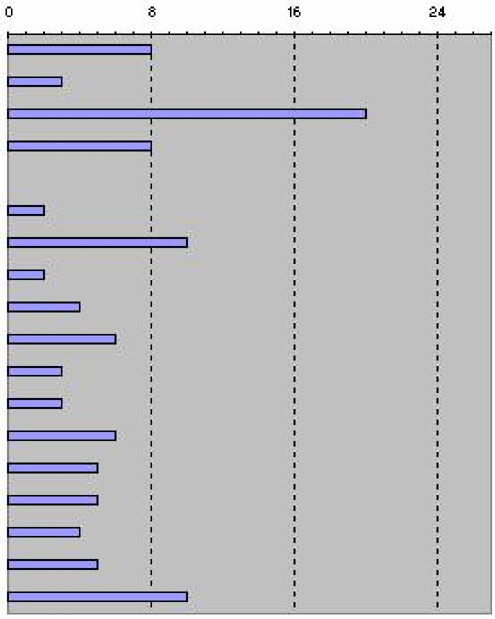
[1] HC = Hazard Characterization
[2] EA = Exposure Assessment
[3] Risk characterization uncertain due to lack of data on exposure.
Where indicated in bold, hazards were characterized as moderately to very serious.

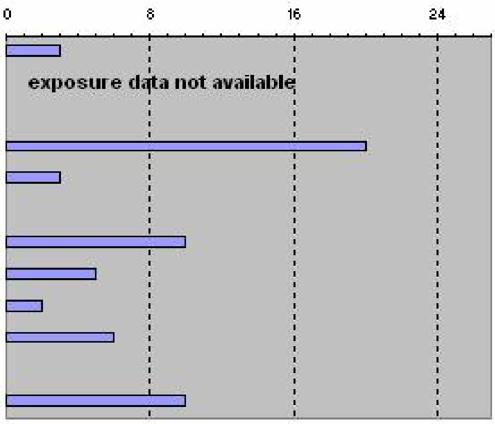
Assessment of risks to welfare of intensively reared calves; subcategory B.a.:

Ba: SMALL GROUPS (RDC)

Associated with		Hazards identified	HC[1]	EA[2]	Risk characterization score (HC x EA)
NUTRITION	◉	Inadequate colostrum intake - quantity	5	3	
	◉	Inadequate colostrum intake - quality	5	2	
	●	Inadequate colostrum intake - duration	5	4	
	○	Iron deficiency (Hb below 4.5 mmol/l)	5	1	
	○	Deficiency of other minerals (Cu, Se)	4	2	
	○	Insufficient access to water (not milk)	4	2	
	?	Allergenic proteins	3		exposure data not available [3]
	○	Inappropriately balanced solid food	3		
	?	Too rich diet (overfeeding)	3		exposure data not available
	○	Underfeeding	4	1	
	○	Too low temperature of milk / -replacer	3	1	
	○	Exposure to contaminated feed	5	1	
	○	No access to natural of artificial teat	2	3	
HOUSING			HC	EA	
	○	High humidity	4	2	
	○	Indoor draughts	3	1	
	●	Inadequate ventilation	5	4	
	○	Poor air quality (amm., bio-aer., dust)	4	2	
	○	Poor insulation against cold	2	1	
	◉	Poor floor conditions, gaps too large	5	2	
	○	Poor floor conditions, too abrasive	2	1	
	○	Poor floor conditions, too slippery	4	1	
	○	Poor floor conditions, too dirty	2	3	
	○	Poor floor conditions, wet floor for lying	3	1	
	○	No bedding	3	1	
	○	Soiled bedding (if bedding used)	3	2	
	○	Insufficient floor space allowance	5	1	
	○	Insufficient light	5	1	
	○	Barren environment	2	2	
	○	Social isolation	5	1	
	◉	Exposure to pathogens	5	2	
MANAGEMENT			HC	EA	
	○	Rough handling on the farm	3	1	
	?	Inadequate health monitoring	4		**exposure data not available**
	●	Continuous restocking (no all-in/out)	4	5	
	○	Poor response to health problems	3	1	
	○	Withholding necessary veterinary care	5		
	◉	Lack of maternal care	2	5	
	○	Mixing calves from different sources	5	1	
	○	Insufficient contact with humans	2	1	
	○	Poorly educated stockperson	3	2	
	○	Castration/ dehorning, no anaesthetics	5		
	◉	Separation from the dam	2	5	







[1] HC = Hazard Characterization

[2] EA = Exposure Assessment

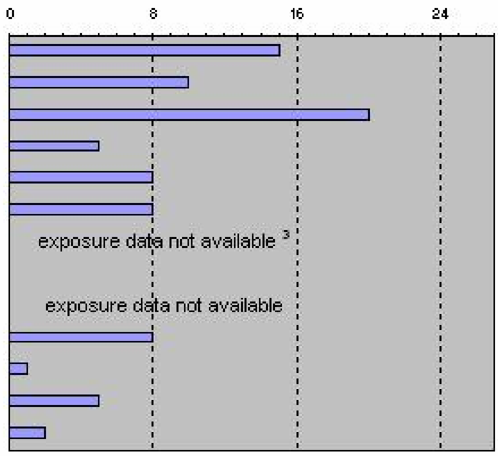
[3] Risk characterization uncertain due to lack of data on exposure.

Where indicated in bold, hazards were characterized as moderately to very serious.

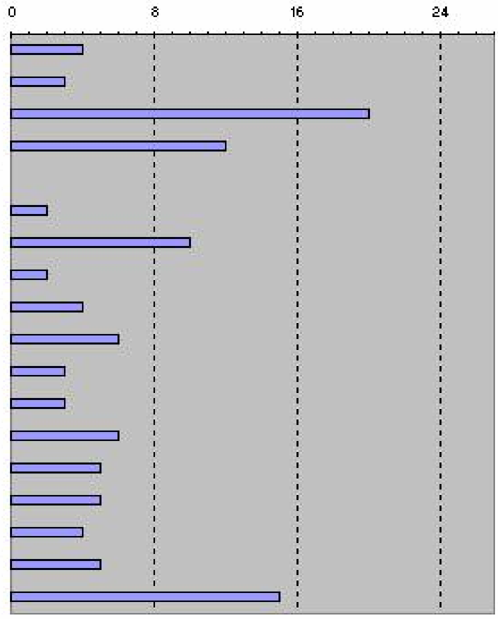
Assessment of risks to welfare of intensively reared calves; subcategory B.b.:

Bb: GROUPS WITH AN AUTOMATIC FEEDING SYSTEM

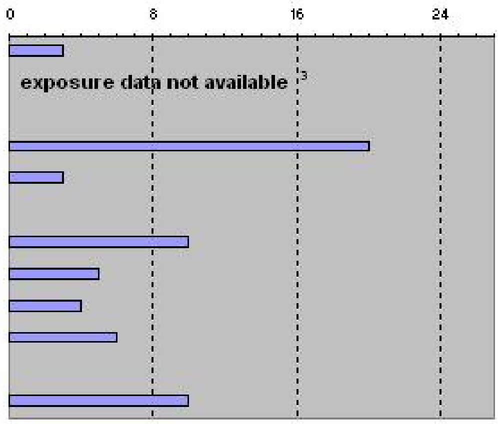
Associated with		Hazards identified	HC[1]	EA[2]
NUTRITION	◍	Inadequate colostrum intake - quantity	5	3
	◍	Inadequate colostrum intake - quality	5	2
	●	Inadequate colostrum intake - duration	5	4
	○	Iron deficiency (Hb below 4.5 mmol/l)	5	1
	○	Deficiency of other minerals (Cu, Se)	4	2
	○	Insufficient access to water (not milk)	4	2
	?	Allergenic proteins	3	
	○	Inappropriately balanced solid food	3	
	?	Too rich diet (overfeeding)	3	
	○	Underfeeding	4	2
	○	Too low temperature of milk / -replacer	3	1
	○	Exposure to contaminated feed	5	1
	○	No access to natural of artificial teat	2	1



Associated with		Hazards identified	HC	EA
HOUSING	○	High humidity	4	1
	○	Indoor draughts	3	1
	●	Inadequate ventilation	5	4
	◍	Poor air quality (amm., bio-aer., dust)	4	3
	○	Poor insulation against cold	2	1
	◍	Poor floor conditions, gaps too large	5	2
	○	Poor floor conditions, too abrasive	2	1
	○	Poor floor conditions, too slippery	4	1
	○	Poor floor conditions, too dirty	2	3
	○	Poor floor conditions, wet floor for lying	3	1
	○	No bedding	3	1
	○	Soiled bedding (if bedding used)	3	2
	○	Insufficient floor space allowance	5	1
	○	Insufficient light	5	1
	○	Barren environment	2	2
	○	Social isolation	5	1
	◍	Exposure to pathogens	5	3



Associated with		Hazards identified	HC	EA
MANAGEMENT	○	Rough handling on the farm	3	1
	?	Inadequate health monitoring	4	
	●	Continuous restocking (no all-in/out)	4	5
	○	Poor response to health problems	3	1
	○	Withholding necessary veterinary care	5	
	◍	Lack of maternal care	2	5
	○	Mixing calves from different sources	5	1
	○	Insufficient contact with humans	2	2
	○	Poorly educated stockperson	3	2
	○	Castration/ dehorning, no anaesthetics	5	
	◍	Separation from the dam	2	5



[1] HC = Hazard Characterization

[2] EA = Exposure Assessment

[3] Risk characterization uncertain due to lack of data on exposure.

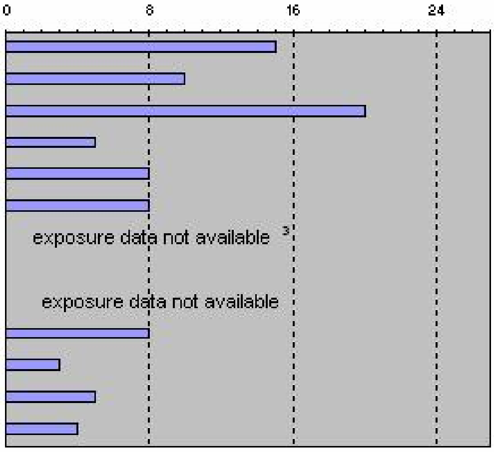
Where indicated in bold, hazards were characterized as moderately to very serious.

Assessment of risks to welfare of intensively reared calves; subcategory B.c.:

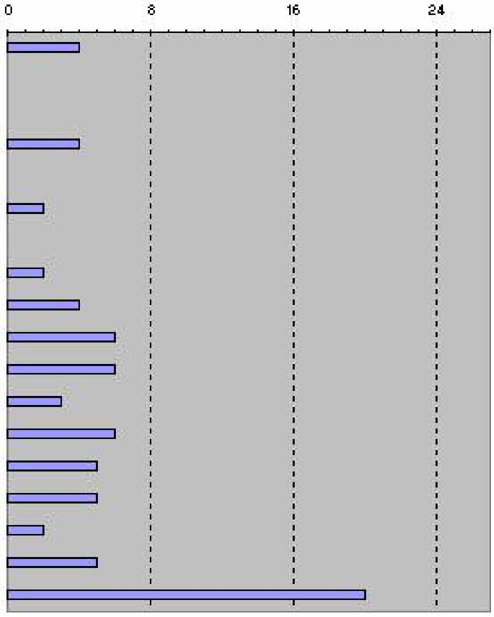
Bc: FEED LOTS (high density groups within outside pens)

Associated with	Hazards identified	HC[1]	EA[2]
NUTRITION			
◍	Inadequate colostrum intake - quantity	5	3
◍	Inadequate colostrum intake - quality	5	2
●	Inadequate colostrum intake - duration	5	4
○	Iron deficiency (Hb below 4.5 mmol/l)	5	1
○	Deficiency of other minerals (Cu, Se)	4	2
○	Insufficient access to water (not milk)	4	2
?	Allergenic proteins	3	
○	Inappropriately balanced solid food	3	
?	Too rich diet (overfeeding)	3	
○	Underfeeding	4	2
○	Too low temperature of milk / -replacer	3	1
○	Exposure to contaminated feed	5	1
○	No access to natural of artificial teat	2	2

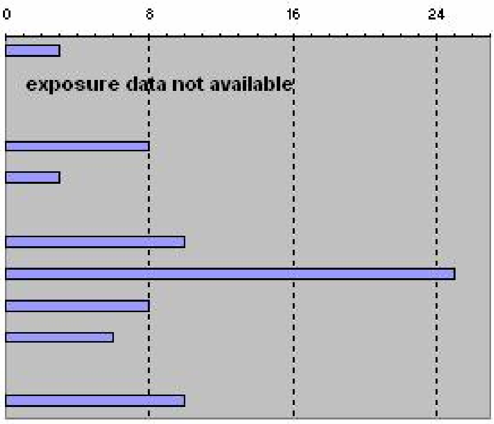
Risk characterization score (HC x EA)



Associated with	Hazards identified	HC	EA
HOUSING			
○	High humidity	4	1
○	Poor air quality (amm., bio-aer., dust)	4	1
○	Poor insulation against cold	2	1
○	Poor floor conditions, too abrasive	2	1
○	Poor floor conditions, too slippery	4	1
○	Poor floor conditions, too dirty	2	3
○	Poor floor conditions, wet floor for lying	3	2
○	No bedding	3	1
○	Soiled bedding (if bedding used)	3	2
○	Insufficient floor space allowance	5	1
○	Insufficient light	5	1
○	Barren environment	2	1
○	Social isolation	5	1
●	Exposure to pathogens	5	4



Associated with	Hazards identified	HC	EA
MANAGEMENT			
○	Rough handling on the farm	3	1
?	Inadequate health monitoring	4	
○	Continuous restocking (no all-in/out)	4	2
○	Poor response to health problems	3	1
○	Withholding necessary veterinary care	5	
◍	Lack of maternal care	2	5
●	Mixing calves from different sources	5	5
○	Insufficient contact with humans	2	4
○	Poorly educated stockperson	3	2
○	Castration/ dehorning, no anaesthetics	5	
◍	Separation from the dam	2	5



[1] HC = Hazard Characterization

[2] EA = Exposure Assessment

[3] Risk characterization uncertain due to lack of data on exposure.

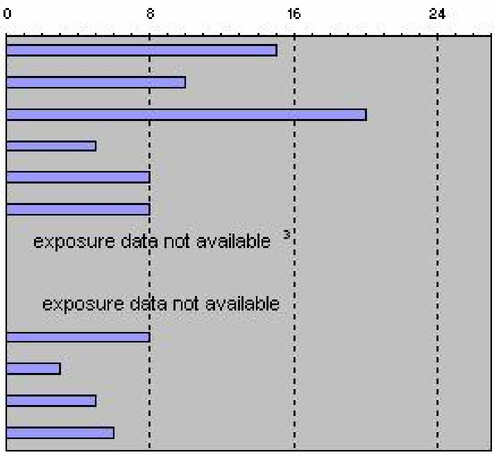
Where indicated in bold, hazards were characterized as moderately to very serious.

Assessment of risks to welfare of intensively reared calves; subcategory B.d.:

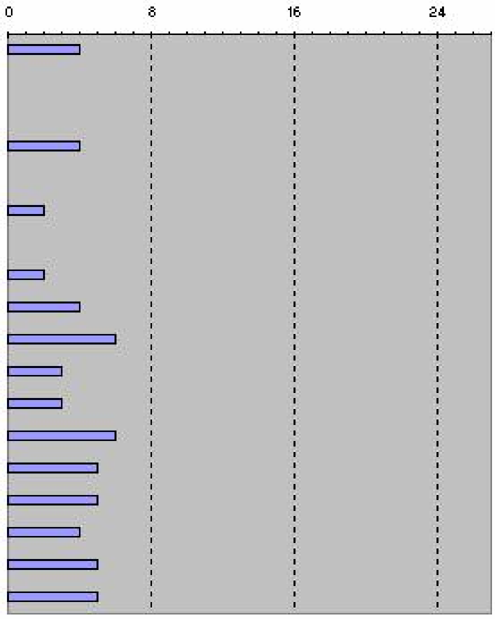
Bd: HUTCHES OUTSIDE

Associated with		Hazards identified	HC[1]	EA[2]
NUTRITION	◍	Inadequate colostrum intake - quantity	5	3
	◍	Inadequate colostrum intake - quality	5	2
	●	Inadequate colostrum intake - duration	5	4
	○	Iron deficiency (Hb below 4.5 mmol/l)	5	1
	○	Deficiency of other minerals (Cu, Se)	4	2
	○	Insufficient access to water (not milk)	4	2
	?	Allergenic proteins	3	
	○	Inappropriately balanced solid food	3	
	?	Too rich diet (overfeeding)	3	
	○	Underfeeding	4	2
	○	Too low temperature of milk / -replacer	3	1
	○	Exposure to contaminated feed	5	1
	○	No access to natural of artificial teat	2	3

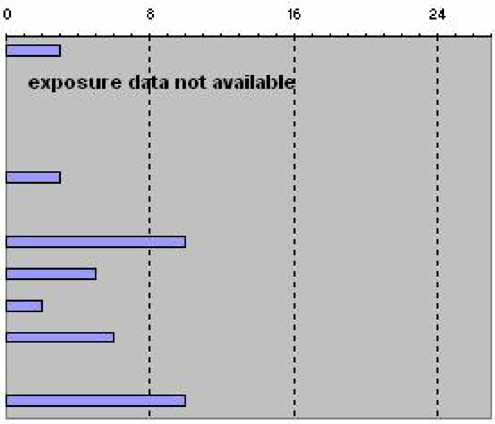
Risk characterization score (HC x EA)



Associated with		Hazards identified	HC	EA
HOUSING	○	High humidity	4	1
	○	Poor air quality (amm., bio-aer., dust)	4	1
	○	Poor insulation against cold	2	1
	○	Poor floor conditions, too abrasive	2	1
	○	Poor floor conditions, too slippery	4	1
	○	Poor floor conditions, too dirty	2	3
	○	Poor floor conditions, wet floor for lying	3	1
	○	No bedding	3	1
	○	Soiled bedding (if bedding used)	3	2
	○	Insufficient floor space allowance	5	1
	○	Insufficient light	5	1
	○	Barren environment	2	2
	○	Social isolation	5	1
	○	Exposure to pathogens	5	1



Associated with		Hazards identified	HC	EA
MANAGEMENT	○	Rough handling on the farm	3	1
	?	Inadequate health monitoring	4	
	○	Poor response to health problems	3	1
	○	Withholding necessary veterinary care	5	
	◍	Lack of maternal care	2	5
	○	Mixing calves from different sources	5	1
	○	Insufficient contact with humans	2	1
	○	Poorly educated stockperson	3	2
	○	Castration/ dehorning, no anaesthetics	5	
	◍	Separation from the dam	2	5



[1] HC = Hazard Characterization

[2] EA = Exposure Assessment

[3] Risk characterization uncertain due to lack of data on exposure.

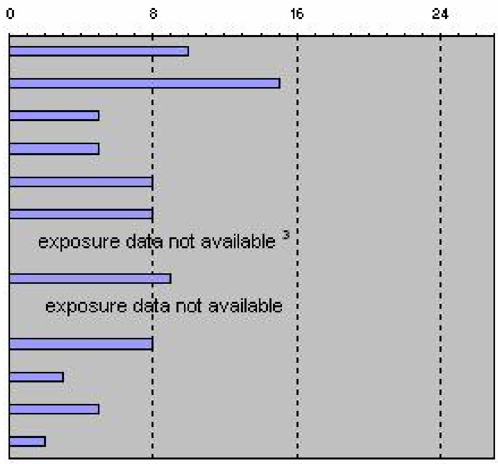
Where indicated in bold, hazards were characterized as moderately to very serious.

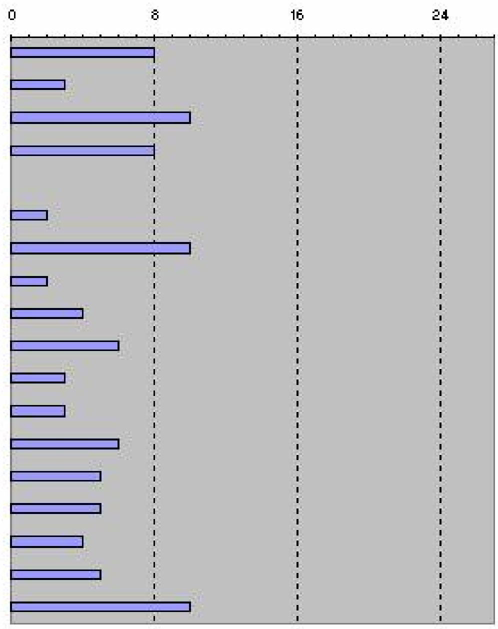
Assessment of risks to welfare of intensively reared calves; subcategory C.a.:

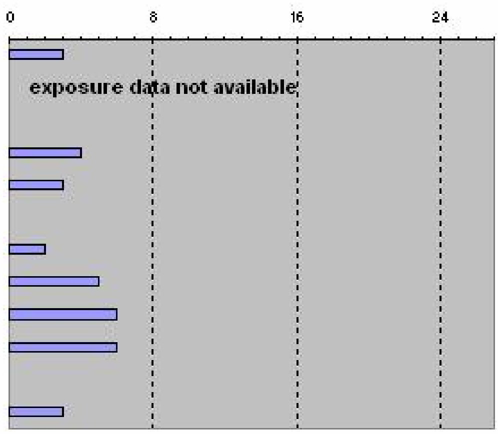
Ca: SUCKLER (BC) GROUPS KEPT INSIDE

Associated with		Hazards identified	HC[1]	EA[2]
NUTRITION	●	Inadequate colostrum intake - quantity	5	2
	●	Inadequate colostrum intake - quality	5	3
	○	Inadequate colostrum intake - duration	5	1
	○	Iron deficiency (Hb below 4.5 mmol/l)	5	1
	○	Deficiency of other minerals (Cu, Se)	4	2
	○	Insufficient access to water (not milk)	4	2
	?	Allergenic proteins	3	
	●	Inappropriately balanced solid food	3	3
	?	Too rich diet (overfeeding)	3	
	○	Underfeeding	4	2
	○	Too low temperature of milk / -replacer	3	1
	○	Exposure to contaminated feed	5	1
	○	No access to natural of artificial teat	2	1
HOUSING			HC	EA
	○	High humidity	4	2
	○	Indoor draughts	3	1
	●	Inappropriate ventilation	5	2
	○	Poor air quality (amm., bio-aer., dust)	4	2
	○	Poor insulation against cold	2	1
	●	Poor floor conditions, gaps too large	5	2
	○	Poor floor conditions, too abrasive	2	1
	○	Poor floor conditions, too slippery	4	1
	○	Poor floor conditions, too dirty	2	3
	○	Poor floor conditions, wet floor for lying	3	1
	○	No bedding	3	1
	○	Soiled bedding (if bedding used)	3	2
	○	Insufficient floor space allowance	5	1
	○	Insufficient light	5	1
	○	Barren environment	2	2
	○	Social isolation	5	1
	●	Exposure to pathogens	5	2
MANAGEMENT			HC	EA
	○	Rough handling on the farm	3	1
	?	Inadequate health monitoring	4	
	○	Continuous restocking (no all-in/out)	4	1
	○	Poor response to health problems	3	1
	○	Withholding necessary veterinary care	5	
	○	Lack of maternal care	2	1
	○	Mixing calves from different sources	5	1
	○	Insufficient contact with humans	2	3
	○	Poorly educated stockperson	3	2
	○	Castration/ dehorning, no anaesthetics	5	
	○	Separation from the dam	3	1

Risk characterization score (HC x EA)







[1] HC = Hazard Characterization

[2] EA = Exposure Assessment

[3] Risk characterization uncertain due to lack of data on exposure.

Where indicated in bold, hazards were characterized as moderately to very serious.

Annex to *The EFSA Journal* (2006) 366 1-36, “The risks of poor welfare in intensive calf farming systems. An update of the Scientific Veterinary Committee Report on the Welfare of Calves”

Scientific Report on

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 written procedure on the 24 of May 2006

EFSA-Q-2005-014

Table of Contents

Summary

EFSA has been requested by the European Commission 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.

In particular the Commission asked EFSA to update the findings of the Scientific Veterinary Committee (Animal Welfare Section) report on the welfare of calves of 9 November 1995 in light of more recent data on this issue. Where relevant the possible food safety implications of different farming systems should also be considered.

In this report a risk assessment was made and the relevant conclusions and recommendations are forming the scientific opinion by the AHAW Panel.

The SVC (1995) report contains information on measurements of welfare, needs of calves, descriptions of current housing systems, chapters on types of feed and feeding systems, weaning of calves, housing and pen design, climate, man-animal relationships, dehorning and castration. Further chapters covered economical considerations of systems and for improving welfare. In the report conclusions were made on general management, housing, food and water and economics.

The present report "The risks of poor welfare in intensive calf farming systems" is an update o the previous SVC report with the exception of economical aspects which are outside of the mandate for this report.

The various factors potentially affecting calves' health and welfare, already extensively listed in the 1995 report of the Scientific Veterinary Committee Animal Welfare section (SVC, 1995), are updated and subsequently systematically determined whether they constitute a potential hazard or risk. To the latter end their severity and likelihood of occurrence in animal (sub) populations were evaluated and associated risks to calf welfare estimated, hence providing the basis for risk managers to decide which measures could be contemplated to reduce or eliminate such risks. In line with the terms of reference the working group restricted itself to (in essence a qualitative) risk assessment

Although it is agreed that welfare and health of calves can be substantially affected in the course of and as a result of transport and slaughter, this report does not consider animal health and welfare aspects of calves during transport and slaughter but such information can be found in a recently issued comprehensive report of the Scientific Committee on Animal Health and Animal Welfare (SCAHAW), on "The welfare of animals during transport (details for horses, pigs, sheep and cattle)" which was adopted on 11 March 2002 (DG SANCO, 2002) and in the EFSA report "Welfare aspects of animal stunning and killing methods" (EFSA, 2004b).

In relation with the food safety aspects, main foodborne hazards associated with calf farming are *Salmonella* spp., human pathogenic-verotoxigenic *Escherichia coli* (HP-VTEC), thermophilic *Campylobacter* spp., *Mycobacterium bovis*, *Taenia saginata cysticercus* and *Cryptosporidium parvum/Giardia duodenalis.* Present knowledge and published data are insufficient to produce a universal risk assessment enabling quantitative food safety categorization/ranking of different types of calf farming systems. Nevertheless, the main risk factors contributing to

increased prevalence/levels of the above foodborne pathogens, as well as generic principles for the risk reductions are known. The latter are based on the implementation of effective farm management (e.g. QA, husbandry, herd health plans, biosecurity) and hygiene measures (e.g. GFP-GHP).

In general, the conclusions made in the previous SVC report remain. However, recent research has provided for some additional conclusions.

The risk analysis is presented in the Tables of Annex 2. The Graphics in this table are not intented to represent numerical relationships but rather qualitative relations. In some instances the exposure could not be estimated due to lack of data, in which cases the risks where labelled "exposure data not available".

The following major and minor risks for poor animal health and welfare have been identified for one or several of the various husbandry systems considered:

Major risks
Inadequate colostrum intake – duration,
Inadequate ventilation, inappropriate airflow, airspeed, temperature for some husbandry systems
Exposure to pathogens causing respiratory and gastrointestinal disorders
Continuous restocking (No "all in – all out")
Mixing calves from different sources

Minor risks
Inadequate colostrum intake – quantity
Inadequate colostrum intake – quality
Insufficient access to water
Insufficiently balanced solid food
High humidity
Indoor draughts
Inadequate ventilation, inappropriate airflow, airspeed temperature for some husbandry sytems
Poor air quality (ammonia, bioaerosols and dust)
Poor floor conditions; gaps too large, too slippery, wet floor for lying, no bedding
Insufficient light for response to visual stimuli
Exposure to pathogens causing respiratory and gastrointestinal disorders
Poor response of farmer to health problems, especially necessary dietary changes
Lack of maternal care
Separation from the dam

For the following hazards there are not enough data available to assess the risks (labelled as "exposure data not available"):

Iron deficiency resulting in Haemoglobin levels below 4.5 mmol/l.
Allergenic proteins
Too rich diet (overfeeding)
Insufficient floor space allowance
Inadequate health monitoring
Inadequate haemoglobulin monitoring

The hazards of iron deficiency and insufficient floor space are considered to be very serious, the hazard of inadequate health monitoring is considered to be serious and the hazards of exposure to inadequate hemoglobin monitoring, allergenic proteins and too rich diet are considered to be moderately serious. For these hazards, there is no consensus on the exposure of calves mainly due to lack of data and that is why it is recommended that further studies should be made to provide evidence for an exposure assessment.

Regarding castration and dehorning (and disbudding) without anaesthetic drugs, there is a variation in relation to national legislation why the risk of poor welfare in relation to castration and dehorning has a wide range between countries.

Tables which clarify the Risk Assessment have been included in Annex 2.

1. Index of Tables

2. Glossary and abbreviations

BVDV
Bovine Virus Diarrhoea Virus

Calf
A calf is a young bovine which is significantly younger and smaller in size than an adult of the same species and breed and which is not reproductively active. There is a gradual transition from a newborn animal, dependent on milk, to an animal with many adult characteristics. Few people would use the term calf for domestic cattle of 10 – 12 months whilst most would call an animal of 5 months or somewhat older a calf. In this report, calf is used for animals of up to 8 months of age.
However, in deciding on the end of the calf stage, any definition based on age or weight is arbitrary. The term calf is not normally restricted to animals that are unweaned or monogastric rather than having some degree of development of the rumen for its specialist function.

Disbudding/dehorning
The removal of the horn bud or the actual horn depending on the breed and the age of the animal.

Endotoxin Unit (EU)
Endotoxin activity of 0.2 ng of Reference Endotoxin Standard, EC-2 or 5 EU/ng (FDA). To convert from EU's into ng, the conversion is 10 EU/ng.

Eutrophication
A process where water bodies receive excess nutrients that stimulate excessive plant growth (i.e. water pollution).

Intensively reared calf
A calf which is not kept extensively at pasture. According to the Council of Europe European Convention for the Protection of Animals kept for Farming Purposes, (Chapter I, Article 1), "modern intensive animal farming systems are systems in which mainly technical facilities are used that are primarily operated automatically and in which the animals depend on the care of and supply from the farmer".

NSAID
Non-steroidal anti-inflammatory drug.

Nursing
The process by which a mother mammal allows a young animal to obtain milk from its teats.

Odds ratio (OR)
The odds ratio is a measure of effect size particularly important in Bayesian statistics and logistic regression.

Omphalitis
Infection of the navel.

Pink veal
Meat produced from animals slaughtered at 28-40 weeks of age and supplied with roughage from at least 2 months of age onwards.

There is not any classification system for veal carcasses agreed across the EU. The only existing classification system would rather relate to a general beef carcass classification system, which comprises the following 5 categories:
1. Meat of young bulls (A)
2. Meat of bulls (B)
3. Meat of steers (C)
4. Meat of cows (D)
5. Meat of heifers (E)

However, these categories are valid for cattle having a live weight of more than 300 kg. Consequently, some member states have issued their own national schemes for veal carcass classification.

In trade, there is agreement between importing and exporting countries that veal originates from calves which were fed predominantly milk replacers, and which displays a light colour. The age limit is around 8 months. Some countries such as The Netherlands market meat of animals of the age of 12 to 14 months, as pink veal. The EU subsidies scheme represents an important incentive for pink veal production.

Risk Analysis Terminology

Dose-reponse Assessment

The determination of the relationship between the magnitude of exposure of calves to a certain hazards and the severity and frequency of associated adverse effects on calf welfare.

Exposure Assessment
The quantitative and qualitative evaluation of the likelihood of hazards to welfare occurring in a given calf population.

Hazard
Any factor, occurring from birth to slaughter, with the potential to cause an adverse effect on calf welfare.

Hazard characterisation
The qualitative and quantitative evaluation of the nature of the adverse effects associated with the hazard. Considering the scope of the exercise of the working group the concerns relate exclusively to calf welfare.

Hazard Identification
The identification of any factor, from birth to slaughter, capable of causing adverse effects on calf welfare.

Risk
A function of the probability of an adverse effect and the severity of that effect, consequent to a hazard for calf welfare.

Risk Characterisation
The process of determining the qualitative or quantitative estimation, including attendant uncertainties, of the probability of occurrence and severity of known or potential adverse effects on welfare in a given calf population based on hazard identification, hazard characterisation, and exposure assessment.

Unaltered remain the following CAC (Codex Alimentarius Commission) definitions (Note: for completeness ALL definitions used by CAC - while not necessarily used in this document - have been included):

Quantitative Risk Assessment
A risk assessment that provides numerical expressions of risk and an indication of the attendant uncertainties (stated in the 1995 expert consultation definition on risk analysis).

Qualitative Risk Assessment
A risk assessment based on data which, while forming an inadequate basis for numerical risk estimations, nevertheless, when conditioned by prior expert knowledge and identification of attendant uncertainties, permits risk ranking or separation into descriptive categories of risk.

Risk Analysis
A process consisting of three components: risk assessment, risk management and risk communication.

Risk Assessment
A scientifically based process consisting of the following steps: i) hazard identification, ii) hazard characterisation, iii) exposure assessment and iv) risk characterisation.

Risk Communication
The interactive exchange of information and opinions concerning the risk and risk management among risk assessors, risk managers, consumers and other interested parties.

Risk Estimate
Output of risk characterisation.

Risk Management
The process of weighing policy alternatives in the light of the results of risk assessment and, if required, selecting and implementing appropriate control options (i.e. prevention, elimination, or reduction of hazards and /or minimization of risks) options, including regulatory measures.

Sensitivity Analysis
A method to examine the behaviour of a model by measuring the variation in its outputs resulting from changes to its inputs.

Transparent
Characteristics of a process where the rationale, the logic of development, constraints, assumptions, value judgements, decisions, limitations and uncertainties of the expressed determination are fully and systematically stated, documented, and accessible for review.

Uncertainty Analysis
A method used to estimate the uncertainty associated with model inputs, assumptions and structure/form.

Sucking
The process by which a young mammal obtains milk from the teat of its mother or another lactating female by sucking.

Veal
The term veal refers to the meat produced from calves, principally those of the species *Bos taurus* and *Bos indicus*. There are several meat products from calves. They are generally distinguished by their colour: “pale” or “white” veal is generally produced from an animal under 6 months of age and fed mostly milk or milk replacer; “pink” veal is generally produced from an animal of up to 8 months fed larger amounts of solid foods and possibly weaned. Meat from calves of 8-12 months is called young beef.

Weaning, weaned
In mammals, weaning is a gradual process during which the young animal receives less and less milk from its dam and consumes more and more solid food. It is accompanied by changes in the dam-offspring relation. In farming, calves are often separated from their dams soon after birth and receive milk (or

milk replacer) from humans or a machine. Although separated from the dam, calves are considered as un-weaned as long as they are fed milk. Suckler calves are left with their dam for some months and are generally weaned some time before the next calving by separating them suddenly from the dam. Calves normally commence eating solid food at 2–3 weeks, although some start earlier, and they eat enough solid food for development of a functional rumen to start by about 6 weeks of age.

A weaned animal is one that no longer needs to suckle and so does not consume milk in any significant quantity indicating that the weaning process has finished.

3. Background

Council Directive 91/629/EEC[1] laying down minimum standards for the protection of calves as amended by Council Directive 97/2/EC[2] requires the Commission to submit to the Council a report, 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 Commission's report will be drawn up also taking into account socio-economic implications of different calf farming systems.

It should be noted that the Scientific Veterinary Committee (Animal Welfare Section) adopted a report on the welfare of calves[3] on 9 November 1995 (SVC, 1995) which should serve as background to the Commission's request and preparation of the new EFSA scientific opinion. In particular the Commission requires EFSA to consider the need to update the findings of the Scientific Veterinary Committee's opinion in light of the availability of more recent data on this issue. Where relevant the possible food safety implications of different farming systems should also be considered.

4. Terms of Reference

EFSA has been requested by the European Commission 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.

In particular the Commission requires EFSA to update the findings of the Scientific Veterinary Committee (Animal Welfare Section) report on the welfare of calves of 9 November 1995 in light of more recent data on this issue. Where relevant the possible food safety implications of different farming systems should also be considered.

The mandate outlined above was accepted by the Panel on Animal Health and Welfare (AHAW) at the Plenary Meeting, on 14/15 March 2005. It was decided to establish a Working Group of AHAW experts (WG) chaired by one Panel member. Therefore the Plenary entrusted a scientific report and risk assessment to a working group under the Chairmanship of Prof. Bo Algers. The members of the working group are listed at the end of this report.

This report is considered for the discussion to establish a risk assessment and the relevant conclusions and recommendations forming the scientific opinion by the AHAW Panel.

According to the mandate of EFSA, ethical, socio-economic, cultural and religious aspects are outside the scope of this scientific opinion.

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[1] OJ L 340, 11.12.1991, p. 28

[2] OJ L 25, 28.1.1997, p. 24

[3] http://europa.eu.int/comm/food/fs/sc/oldcomm4/out35_en.pdf

5. General Approach

In 1995, the Scientific Veterinary Committee of the European Commission published the Report on the Welfare of Calves.

The SVC (1995) report contains information on measurements of welfare, needs of calves, descriptions of current housing systems, chapters on types of feed and feeding systems, weaning of calves, housing and pen design, climate, man-animal relationships, dehorning and castration. Further chapters covered economic considerations of systems and for improving welfare. In the report conclusions were made on general management, housing, food and water and economics.

The present report "The risks of poor welfare in intensive calf farming systems" is an update of the previous SVC report with the exception of economic aspects which are out of the mandate for this report. This report represents an update of the previous SVC Report (1995) with a risk assessment perspective.

Factors which are important for calf welfare include housing (space and pen design, flooring and bedding material, temperature, ventilation and air hygiene), feeding (liquid feed, concentrates, roughage) and management (grouping, weaning, human-animal relations).

The measures used to assess welfare include behavioural and physiological measures, patho-physiological measures and clinical signs as well as production measures.

As explained in the glossary, in this report young bovines are called calves up to a maximum of eight months of age and veal is the meat of a calf. Countries with substantial production of veal are France, Italy, The Netherlands, Belgium, Spain and Germany. Significant veal production exists also in Portugal, Austria and Denmark, The production of white veal, from calves that have been fed predominantly milk replacer and which has a light colour, takes place largely in France, The Netherlands, Belgium and Italy. The EU subsidies scheme represents an important incentive for pink veal production. Most calves produced for further rearing are in France, Germany, UK, Ireland and Italy. The ways of keeping calves vary considerably from country to country and between breeds. Most dairy calves are separated from their dam at birth and artificially fed whereas calves from beef breeds generally suckle their dam.

According to EU statistics, in 2004 in the EU (25) 4,499,381 calves were reared for slaughter (Table 1) and 20,630,237 calves were reared for other reasons than slaughter (Table 2). In total (Table 3) 755,226 tonnes of calf meat were produced in EU (15) which probably implies that about 825,000 tonnes were produced in EU (25) during 2004. Human consumption of meat from calves decreased slightly from 1995 to 2001 in EU (15) (Table 4).

Table 5.1. Calves reared for slaughter in EU

Calves Reared for Slaughter					
item	*scal* CALVES FOR SLAUGHTER[1]				
element	*head* Livestock (1000 hds)				
Year	1995	1998	2001	2003	2004
European Union (n=25)	:	:	:	4,439,644	4,499,381
European Union (n=15)	3,654,750	3,708,188	4,023,686	3,954,168	4,073,374
Belgium	163,268	162,695	180,223	162,642	155,806
Czech Republic	:	:	:	63,000	50,200
Denmark	6,000	6,000	6,000	6,000	6,000
Germany	180,348	133,615	104,319	121,995	124,938
Estonia	:	:	16,800	7,300	3,500
Greece	51,000	38,000	106,000	149,000	145,000
Spain	1,232,000	1,400,000	1,470,235	1,510,415	1,550,232
France	726,800	689,556	762,002	633,000	646,000
Ireland	:	:	:	:	:
Italy	459,000	393,000	496,264	413,000	445,000
Cyprus	:	5,300	:	9,840	9,636
Latvia	:	28,200	68,600	64,300	63,500
Lithuania	:	113,200	81,300	83,700	84,100
Luxembourg (Grand-Duché)	1,120	2,327	3,294	2,546	2,623
Hungary	:	:	67,000	71,000	62,000
Malta	:	:	:	:	:
Netherlands	668,000	684,000	676,000	748,382	775,000
Austria	64,558	52,363	68,080	57,669	62,836
Poland	:	168,700	126,928	138,838	113,351
Portugal	60,000	64,000	78,557	65,066	85,067
Slovenia	:	:	14,138	10,044	10,392
Slovakia	60,000	78,000	68,982	37,454	29,328
Finland	7,000	8,500	9,400	8,00	2,500
Sweden	23,100	29,300	25,167	22,600	22,612
United Kingdom	12,556	44,832	38,145	53,853	49,760

[1]: item and element selected in the EUROSTAT Database to make the query and extract the data

Table 5. 2. Calves reared for other purpose than for Slaughter in EU

Calves other than for Slaughter					
item	*ocal* OTHER CALVES[1]				
element	*head* Livestock (1000 hds)				
Year	1995	1998	2001	2003	2004
25 European Union (25 countries)	:	:	21,422,261	20,755,632	20,630,237
15 European Union (15 countries)	21,237,481	20,401,682	19,243,122	18,692,526	18,577,455
Belgium	769,099	700,984	618,207	552,236	557,195
Czech Republic	:	:	461,000	356,000	341,600
Denmark	754,000	662,000	578,000	543,000	534,000
Germany	5,061,080	4,618,900	4,309,431	3,976,641	3,955,034
Estonia	:	:	53,100	65,000	63,400
Greece	109,000	117,000	38,000	46,000	46,000
Spain	525,000	610,000	700,296	725,677	705,618
France	4,467,100	4,447,481	4,514,831	4,328,000	4,350,000
Ireland	1,631,408	1,789,525	1,879,430	1,751,100	1,746,006
Italy	1,796,000	1,865,000	1,498,068	1,595,000	1,510,000
Cyprus	:	19,530	17,990	10,836	12,914
Latvia	:	81,100	43,400	44,800	46,900
Lithuania	:	93,200	82,700	105,200	104,700
Luxembourg (Grand-Duché)	52,225	53,087	51,272	47,881	49,321
Hungary	:	:	138,000	1240,000	128,000
Malta	:	:	5,275	4,909	5,467
Netherlands	862,000	742,000	681,000	573,517	620,000
Austria	626,896	582,750	590,850	583,971	584,110
Poland	:	1374,800	1151,253	1083,401	1091,850
Portugal	312,000	314,000	321,757	323,482	313,291
Slovenia	:	:	122,855	120,859	126,298
Slovakia	242,000	118,000	103,566	148,101	131,653
Finland	418,700	378,200	345,300	327,300	325,863
Sweden	560,00	496,400	483,211	487,300	486,663
United Kingdom	3,292,973	3,024,355	2,633,469	2,831,421	2,794,354

[1]: item and element selected in the EUROSTAT Database to make the query and extract the data

Table 5.3. Production of calf meat from slaughtering in EU

Calf Meat from Slaughtering (in 1000 t)					
item	*calm* Calves Meat[1]				
element	*psla* Slaughterings in 1000 t				
Year	1995	1998	2001	2003	2004
25 **European Union (25 countries)**	:	:	:	:	:
15 **European Union (15 countries)**	796,630	768,068	756,625	764,308	755,226
Belgium	53,779	46,284	46,874	50,421	48,764
Czech Republic	6,000	5,000	0,745	2,250	0,856
Denmark	5,500	5,250	2,930	2,139	2,020
Germany	60,453	55,741	46,124	40,295	45,606
Estonia	:	:	:	0,500	0,560
Greece	11,999	11,450	13,710	14,160	13,720
Spain	3,664	24,541	33,735	39,470	31,819
France	258,629	246,258	250,431	243,418	233,884
Ireland	0	0,500	0,300	0,300	0
Italy	181,538	147,180	156,768	147,206	140,615
Cyprus	3,400	2,100	:	0	0
Latvia	:	:	:	3,928	3,000
Lithuania	:	:	:	2,946	2,907
Luxembourg (Grand-Duché)	0,238	0,431	0,535	0,739	0,735
Hungary	:	:	:	0,577	0,655
Malta	:	:	:	0	:
Netherlands	193,902	197,619	164,586	186,468	197,562
Austria	12,560	10,885	11,227	9,535	9,539
Poland	39,000	40,000	38,000	27,314	9,295
Portugal	9,151	15,784	21,955	23,241	23,122
Slovenia	:	1,800	:	:	2,530
Slovakia	:	:	:	0	0
Finland	0,964	1,094	0,887	0,659	0,586
Sweden	3,244	3,959	4,07	4,041	4,578
United Kingdom	1,009	1,092	2,493	2,217	2,675

[1]: item and element selected in the EUROSTAT Database to make the query and extract the data

Table 5.4. Gross human apparent consumption of bovine meat in EU

Gross human apparent consumption of bovine meat					
variable	*app_hcons* Gross human apparent consumption[1]				
consitem	*hc_01121* Meat : Cattle (1000 t)				
Year	1995	1998	2001	2003	2004
25 European Union (25 countries)	:	:	:	:	:
15 European Union (15 countries)	7,471,216	7,315,695	6,780,760	:	:
Belgium	:	:		:	:
Czech Republic	:	:	:	:	:
Denmark	92,000	103,000	120,000	148,000	152,000
Germany	1,357,476	1,241,297	818,391	1,030,773	1,043,272
Estonia	:	:	:	:	:
Greece	204,509	221,597	197,340	188,760	182,030
Spain	490,500	616,100	523,320	638,800	655,300
France	1,650,600	1,615,100	1,553,800	1,670,300	1,650,000
Ireland	52,000	68,000	66,000	:	:
Italy	1,480,000	1,403,000	1,315,000	1,416,000	1,396,000
Cyprus	:	:	:	:	:
Latvia	:	:	:	:	:
Lithuania	:	:	:	:	:
Luxembourg (Grand-Duché)	:	:	12,425	:	:
Hungary	:	:	:	:	:
Malta	:	:	:	10,500	:
Netherlands	306,000	296,000	303,000	310,000	:
Austria	157,311	149,445	148,600	152,600	144,100
Poland	:	:	:	251,000	:
Portugal	174,000	158,000	158,000	180,000	:
Slovenia	:	:	:	:	:
Slovakia	:	:	:	:	:
Finland	97,320	99,700	92,500	96,000	99,400
Sweden	160,300	174,156	182,262	212,850	:
United Kingdom	1,026,200	955,300	1,113,100	906,800	1,179,000

[1]: item and element selected in the EUROSTAT Database to make the query and extract the data

5.1. Statement of purpose of the Risk Assessment Exercise

The working group set out to produce a document in which the various factors potentially affecting calves' health and welfare [already extensively listed in the 1995 report of the Scientific Veterinary Committee Animal Welfare section (SVC, 1995), are updated and subsequently to systematically determine whether these factors constitute a potential hazard or risk. To the latter end their severity and likelihood of occurrence in animal (sub) populations were evaluated and associated risks to calf welfare estimated, hence providing the basis for risk managers to decide which measures could be contemplated to reduce or eliminate such risks. It should be noted, however, that this does not imply that a hazard that has a serious effect on just a few animals should not be dealt with by managers on farm level as the suffering imposed on some animals constitute a major welfare problem for those individuals.

5.2. The chosen approach

In line with the terms of reference the working group restricted itself to (in essence qualitative) risk assessment, i.e. only one of three elements essential to risk analysis
A risk assessment approach was followed, similar to the one generally adopted when assessing microbiological risks, i.e. along the lines suggested at the 22nd session of the Codex Alimentarius Commission (CAC, 2002). Incidentally, these guidelines have been characterized by the CAC as 'interim' because they are subject to modifications in the light of developments in the science of risk analysis and as a result of efforts to harmonize definitions across various disciplines. CAC's guidelines are in essence exclusively formulated for the purpose of assessing risks related to microbiological, chemical or physical agents of serious concern to public health.

Consequently - considering their disciplinary focus - the working group had to adapt the CAC definitions to serve their purpose. These adapted definitions, have, in alphabethical order, been included in Chapter 2 (see Risk Analysis Terminology).

The objectives of this report 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.

Where relevant, food safety implications of different farming systems are also considered.

The report is structured in five major parts. The first three follow the Scientific Veterinary Committee’s previous report “On the welfare of calves” with introductory chapters 4-7 on background, measurements and needs in relation to calf welfare, chapter 8 describing housing, diet and management and chapter 9 describing comparison of systems and factors. In chapter 10 common disease and use of antibiotics is described. The other two parts involve aspects of meat quality and food safety (chapter 11) and the risk assessment (chapter 12). Conclusions and recommendations from the previous SVC document together with updated conclusions derived from recent research findings are presented in the Scientific Opinion (www.efsa.eu.int).

5.3. Effect of transport and slaughter on calves' health and welfare

Although it is agreed that welfare and health of calves can be substantially affected in the course of and as a result of transport, this report does not consider animal health and welfare aspects of calves during transport because there is already a comprehensive recent report of the Scientific Committee on Animal Health and Animal Welfare (SCAHAW), on "The welfare of animals during transport (details for horses, pigs, sheep and cattle)" which was adopted on 11 March 2002 (DG SANCO, 2002). The report takes into account all aspects related with transport that could affect the health and welfare of cattle and calves, including the direct effects of transport on the animals and the effects of transport on disease transmission. The loading methods and handling facilities for cattle, the floor space allowance, the relationships of stocking and the density requirements, the vehicle design, space requirements and ventilation for cattle transporters (see also the AHAW Scientific Opinion related to Standards for the microclimate inside animal road transport vehicles; EFSA, 2004), the behaviour of cattle during road transport, the road conditions, long distance transport and the travel times are also reviewed. Recommendations for all these aspects are also given in that report.

6. Welfare and its assessment

The following general requirements in relation to animal welfare were annexed as a protocol to the EU Treaty of Amsterdam in 1997: "In formulating and implementing the Community's agriculture, fisheries, transport, and internal market policies, the Community and the Member States shall pay full regard to the welfare requirements of animals, while respecting the legislative provisions and customs of Member States relating to religious rites, cultural traditions and regional heritage."

In the introduction to the proposed EU constitution, the following extended wording is included: "In formulating and implementing the European Union's agriculture, fisheries, transport, internal market, research and technological development and space policies, the Union and the Member States shall pay full regard to the welfare requirements of animals, as sentient beings, while respecting the legislative provisions and customs of Member States relating to religious rites, cultural traditions and regional heritage."

This wording reflects the ethical concerns of the public about the quality of life of the animals. It also takes into account customs and cultural traditions. Farm animals are subject to human imposed constraints and for a very long time the choice of techniques has been based primarily on the efficiency of production systems for the provision of food. However it is an increasingly held public view that we should protect these animals against mistreatment and poor welfare.

In order to promote good welfare and avoid suffering, a wide range of needs must be fulfilled. These needs may require the animal to obtain resources, receive stimuli or express particular behaviours (Hughes and Duncan, 1988; Jensen and Toates, 1993; Vestergaard, 1996).

To be useful in a scientific context, the concept of welfare has to be defined in such a way that it can be scientifically assessed. This also facilitates its use in legislation and in discussions amongst farmers and consumers.

Welfare is clearly a characteristic of an individual animal and is concerned with the effects of all aspects of its genotype and environment on the individual (Duncan, 1981). Broom (1986) defines it as follows: the welfare of an animal is its state as regards its attempts to cope with its environment. Welfare therefore includes the extent of failure to cope, which may lead to disease and injury, but also ease of coping or difficulty in coping. Furthermore, welfare includes pleasurable mental states and unpleasant states such as pain, fear and frustration (Duncan, 1996; Fraser and Duncan, 1998). Feelings are a part of many mechanisms for attempting to cope with good and bad aspects of life and most feelings must have evolved because of their beneficial effects (Broom, 1998). Although feelings cannot be measured directly, their existence may be deduced from measures of physiology, behaviour, pathological conditions, etc. Feelings cannot be directly measured and therefore care is necessary to avoid uncritical anthropomorphic interpretations (Morton et al., 1990). Good welfare can occur provided the individual is able to adapt to or cope with the constraints to which it is exposed. Hence, welfare varies from very poor to very good and can be scientifically assessed.

Measures which are relevant to animal welfare during housing, i.e. largely long-term problems, are described by Broom and Johnson (1993) and by Broom (1996, 2000, 2004a, b). Production criteria have a place in welfare assessment. However, although failure to grow, reproduce etc. often indicates poor welfare, high levels of production do not necessarily indicate good welfare.

Physiological measurements can be useful indicators of poor welfare. For instance, increased heart-rate, adrenal activity, or adrenal activity following ACTH challenge, or reduced heart-rate variability, or immunological response following a challenge, can all indicate that welfare is poorer than in individuals which do not show such changes. The impaired immune system function and some of the physiological changes can indicate the pre-pathological state (Moberg, 1985). In interpreting physiological measurements such as heart rate and adrenal activity it is important to take account of the environmental and metabolic context, including activity level.

Behavioural measures are also of particular value in welfare assessment (Wiepkema, 1983). The fact that an animal avoids an object or event, strongly gives information about its feelings and hence about its welfare (Rushen, 1986). The stronger the avoidance the worse the welfare whilst the object is present or the event is occurring. An individual, whom is completely unable to adopt a preferred lying posture despite repeated attempts will be assessed as having poorer welfare than one which can adopt the preferred posture. Other abnormal behaviour which includes excessively aggressive behaviour and stereotypes, such as tongue-rolling in calves, indicates that the perpetrator's welfare is poor. Very often abnormal activities derive from activities that cannot be expressed but for which the animal is motivated. For example, calves deprived of solid foods and hence lacking the possibility of nutritive biting, develop non-nutritive biting. Whether physiological or behavioural measures indicate that coping is difficult or that the individual is not coping, the measure indicates poor welfare.

Studies of the brain inform us about the cognitive ability of animals and they can also tell us how an individual is likely to be perceiving, attending to, evaluating, coping with, enjoying, or disturbed by its environment so can give direct information about welfare (Broom and Zanella, 2004). In studies of welfare, we are especially interested in how an individual feels. As this depends upon high-level brain processing, we have to investigate brain function. Abnormal behaviour and preferred social, sexual and parental situations may have brain correlates. Brain measures can sometimes explain the nature and magnitude of effects on welfare.

The word "health", like "welfare", can be qualified by "good" or "poor" and varies over a range. However, health refers to the state of body systems, including those in the brain, which combat pathogens, tissue damage or physiological disorder (Broom and Kirkden, 2004; Broom, 2006). Welfare is a broader term than health, covering all aspects of coping with the environment and taking account of a wider range of feelings and other coping mechanisms than those associated with physical or mental disorders. Disease, implying that there is some pathology, rather than just pathogen presence, always has some adverse effect on welfare (Broom and Corke, 2002).

The pain system and responses to pain are part of the repertoire used by animals to help them to cope with adversity during life. Pain is clearly an important part of poor welfare (Broom, 2001b). However, prey species such as young cattle and sheep may show no behavioural response to a significant degree of injury (Broom and Johnson, 1993).

In some situations responses to a wound may not occur because endogenous opioids which act as analgesics are released. However, there are many occasions in humans and other species when suppression of pain by endogenous opioids does not occur (Melzack et al., 1982). Studies of the brain inform us about the cognitive ability of animals and they can also tell us how an individual is likely to be perceiving, attending to, evaluating, coping with, enjoying, or disturbed by its environment so can give direct information about welfare (Broom and Zanella, 2004). In studies of welfare, we are especially interested in how an individual feels. As this depends upon high-level brain processing, we have to investigate brain function. Abnormal behaviour and preferred social, sexual and parental situations may have brain correlates. Brain measures can sometimes explain the nature and magnitude of effects on welfare.

The majority of indicators of good welfare which we can use are obtained by studies demonstrating positive preferences by animals (Dawkins, 1990). Methods of assessing the strengths of positive and negative preferences have become much more sophisticated in recent years. The price which an animal will pay for resources, or pay to avoid a situation, may be, for example, a weight lifted or the amount of energy required to press a plate on numerous occasions. The demand for the resource, i.e. the amount of an action which enables the resource to be obtained, at each of several prices can be measured experimentally. This is best done in studies where the income available, in the form of time or energy, is controlled in relation to the price paid for the resource. When demand is plotted against price, a demand curve is produced. In some studies, the slope of this demand curve has been measured to indicate price elasticity of demand but in recent studies (Kirkden et al., 2003) it has become clear that the area under the demand curve up to a particular point, the consumer surplus, is the best measure of strength of preference. Once we know what animals strongly prefer, or strongly avoid, we can use this information to identify situations which are unlikely to fulfil the needs of animals and to design better housing conditions and management methods (Fraser and Matthews, 1997). However, as pointed out by Duncan (1978, 1992), all data from preference studies must be interpreted taking account of the possibilities that, firstly, an individual may show a positive preference for something in the short-term which results in its poor welfare in the long-term, and secondly, that a preference in a simplified experimental environment needs to be related to the individual's priorities in the more complicated real world.

Each assessment of welfare will pertain to single individual and to a particular time range. In the overall assessment of the impact of a condition or treatment on an individual, a very brief period of a certain degree of good or poor welfare is not the same as a prolonged period.

However, a simple multiplicative function of maximum degree and duration is often not sufficient. If there is a net effect of poor welfare and everything is plotted against time, the best overall assessment of welfare is the area under the curve thus produced (Broom, 2001c).

7. The needs and functioning of calves

7.1. The concept of needs

In assessing the needs and functioning of calves, many different approaches can be taken. One is to study, at a fundamental level, the physiology and behaviour of cattle and the ways in which they have evolved, in order to try to understand their causation and function.

Needs are in the brain but may be fulfilled by obtaining resources, physiological change, or carrying out a behaviour. In order to conclude that a need exists to show certain behaviour, it is necessary to demonstrate that the calves used in modern production systems are strongly motivated to show the behaviour and that, if the need is not provided for, there are signs of poor welfare such as abnormal behaviour or physiology or pathological effects (see chapter 6). Where the housing design allows the animals to show the behaviour that they need to show, this will promote the avoidance of poor welfare.

A need is a requirement, which is a consequence of the biology of the animal, to obtain a particular resource or respond to a particular environmental or bodily stimulus. An animal may have a need that results in the existence at all times of mechanisms within the brain and abilities to perceive stimuli and respond appropriately. However, this does not mean that every individual at all times needs to carry out the response. For example, a calf has a need to avoid attack by a predator but it does not need to carry out anti-predator behaviour if no individual perceived as a predator is present.

There are some needs which require urgent fulfilment, otherwise the body functioning will be impaired and in the medium or long term, the animal may suffer. For example, an adequate amount of an essential nutrient or avoidance of exposure to a serious disease. There are other needs which, if not fulfilled lead to frustration and excessive activities in an attempt to fulfil the need. The resulting poor welfare may be extreme and prolonged.

Needs to avoid predation and other danger mean that animals have a negative experience in some situations. Close human presence and handling of animals may elicit physiological and behavioural anti-predator responses. The avoidance of such situations can also be considered as a need.

Calves require space to perform activities such as resting, feeding, exploring, interacting and escaping from perceived danger. To assess what risks of poor welfare are involved when the housing circumstances do not allow certain activities, it can be helpful to consider why the calves are intrinsically motivated to perform the activities.

The selection criteria applied to modern cattle genotypes have resulted in changes in morphological phenotype. Although these have not altered the categories of needs of calves, they may have altered rates of growth and energy partitioning so that the timing of problems and the probability that they will arise may be changed.

7.2. The needs of calves

The overall need of calves is to maintain bodily integrity while growing and preparing for adult life. In order to do this, calves have a series of needs that are relevant to the housing and management conditions imposed upon them by humans. The needs of calves are described in detail by Broom (1991, 1996). In listing needs and in later consideration of how to provide for them, it is assumed that extreme human actions, such deliberately creating a large wound or infecting an animal with a dangerous pathogen, will not occur.

The list of needs is not in order of importance. Some of the needs mentioned here are discussed at greater length in the previous report.

7.2.1. To breathe

Calves need air that has sufficient oxygen and a low level of noxious gases in it. Calves may be adversely affected by some of the gaseous products of the breakdown of animal faeces and they show preferences that help them to avoid any harm that they may cause.

7.2.2. To rest and sleep

Calves need to rest and sleep in order to recuperate and avoid danger. They need to use several postures which include one in which they rest the head on the legs and another in which the legs are fully stretched out (De Wilt, 1985; Ketelaar de Lauwere and Smits, 1989, 1991). Sleep disruption may occur if comfortable lying positions cannot be adopted or if there is disturbance to lying animals because they are trodden on or otherwise disturbed by other calves.

7.2.3. To exercise

Exercise is needed for normal bone and muscle development. Calves choose to walk at intervals if they can, show considerable activity when released from a small pen and have locomotor problems if confined in a small pen for a long period (Warnick et al., 1977; Dellmaier et al., 1985; Trunkfield et al., 1991).

7.2.4. To avoid fear

Calves living in natural conditions would be very vulnerable to predation when young. As a consequence, the biological functioning of calves is strongly adapted to maximise the chance of recognition of danger and escape from it. Calves respond to sudden events and approaches by humans or other animals perceived to be potentially dangerous with substantial sympathetic nervous system and hypothalamic-pituitary-adrenocortical (HPA) changes. These physiological changes are followed by rapid and often vigorous behavioural responses. Fear is a major factor in the life of calves and has a great effect on their welfare.

7.2.5. To feed and drink

7.2.5.1. *Sucking*

The calf needs to attempt to obtain nutrients at a very early stage after birth and shows behavioural responses that maximise this chance. As a consequence, from an early age, calves have a very strong need to show sucking behaviour and if a calf is not obtaining milk from a real or artificial teat, it sucks other objects (Broom, 1982, 1991; Metz, 1984; Hammell et al., 1988; Jung and Lidfors, 2001). The need of the calf is not just to have the colostrum or milk in the gut but also to carry out the sucking behaviour on a suitable object (Jensen, 2003).

Further, the sucking is of importance for the release of gastrointestinal hormones. It has been shown in calves that oxytocin is released during milk ingestion. The amount released, however, was less in calves drinking their milk from a bucket compared with calves suckling the dam (Samuelsson, 1996). Peripheral oxytocin stimulates the release of glucagon from the pancreas whereas central oxytocin increases hunger and the release of gastrointestinal hormones promoting growth (Stock et al., 1990; Björkstrand, 1995).

7.2.5.2. *Drinking*

In the early days after birth, calves are motivated to suck and obtain milk. However, calves also have a need to obtain sufficient water and will drink water even when fed milk. If the temperature is high, calves will drink water if it is available and sick calves will also choose to drink water. If water is not available, over-heated calves and sick calves may become dehydrated. Sick calves may become dehydrated even when water is offered. Calves with acidosis with or without diarrhoea often lose their suckling reflex. This may also happen in calves with hypoglycaemia and septicaemia (Berthold, pers. com).

7.2.5.3. *Rumination*

After the first few weeks of life, calves attempt to start ruminating. If they have received no solid material in their diet, calves still try to ruminate but cannot show the full rumination behaviour.

7.2.5.4. *Feed manipulation*

In addition to the need to suck when young, calves need to manipulate material with their mouths. They try to do this whether or not they have access to solid material and they will seek out solid material that they subsequently manipulate.

7.2.6. To obtain nutrients

7.2.6.1. *Feed*

A variety of nutrients are needed by calves. If any are lacking in the feed, there will be adverse consequences if essential nutrients cannot be provided by other means. Sufficient iron is needed to allow normal activity and to minimise disease.

7.2.6.2. *Water*

As explained above, calves need sufficient water and their needs are greater if over-heated or diseased.

7.2.7. To have normal gut development

Normal calf anatomical, physiological and behavioural development occurs only if the calves have solid food to eat (Van Putten and Elshof, 1978; Webster, 1984; Webster et al., 1985). Calves eat solid food better when water is offered simultaneously. Certain rapidly digestible carbohydrates are necessary for the development of ruminal papillae with associated physiological development and fibrous roughage helps the anatomical development of the rumen. So it is clear that calves need appropriate solid food in their diet after the first few weeks of life; first, food that is digested rapidly and provide fatty acids; then fibrous foods. Rumen development is enhanced when calves are fed with concentrates, water and roughage such as hay.

7.2.8. To explore

Exploration is important as a means of preparing for the avoidance of danger and is a behaviour shown by all calves (Kiley Worthington and de la Plain, 1983; Fraser and Broom, 1990). Exploration is also valuable for establishing where food sources are located. Calves need to explore and it may be that higher levels of stereotypes (Dannemann et al., 1985) and fearfulness (Webster and Saville, 1981) in poorly lit buildings or otherwise inadequate conditions are a consequence of inability to explore.

7.2.9. To have social contact

7.2.9.1. *Maternal contact*

The needs of young calves are met most effectively by the presence and actions of their mothers. In the absence of their mothers, calves associate with other calves if possible and they show much social behaviour.

7.2.9.2. *Other*

The need to show full social interaction with other calves is evident from calf preferences and from the adverse effects on calves of social isolation (Broom and Leaver, 1978; Dantzer et al., 1983; Friend et al., 1985; Lidfors, 1993).

7.2.10. To minimise disease

During the first few hours of life, the vigorous attempts of the calf to find a teat and suckle should result in obtaining colostrum from the mother. This colostrum includes immunoglobulins that provide passive protection against infectious agents. Hence the needs of the calf have an evident function that is not just nutritional. Calves also show preferences to avoid grazing close to faeces. They also react to some insects of a type which may transmit disease. If infected with pathogens or parasites, calves will show sickness behaviour that tends to minimise the adverse effects of disease (Broom and Kirkden, 2004).

Young calves, less than four weeks of age, are not well adapted to cope with stressful events such as handling and transport, often suffering very high rates of mortality and the younger the calves are, the higher their mortality (Staples and Haugse, 1974; Mormède et al., 1982) many succumbing to pneumonia or scouring, within four weeks of arrival at the rearing unit (Staples and Haugse, 1974). An inability to mount an effective glucocorticoid response, which is adaptive in the short term, may be a contributing factor to the high levels of morbidity and mortality which occur in young calves (Knowles et al., 1997) as may neutrophilia (Simensen et al., 1980; Kegley et al., 1997), lymphopaenia (Murata et al., 1985) and suppression of the cell mediated immune response (Kelley et al., 1981; MacKenzie et al., 1997).

7.2.11. To groom

Grooming behaviour is important as a means of minimising disease and parasitism and calves make considerable efforts to groom themselves thoroughly (Fraser and Broom, 1990). Calves need to be able to groom their whole bodies effectively.

7.2.12. To thermoregulation

Calves need to maintain their body temperature within a tolerable range. They do this by means of a variety of behavioural and physiological mechanisms.

7.2.12.1. *Selection of location*

When calves are over-heated, or when they detect that they are likely to become over-heated, they move to locations that are cooler. If no such movement is possible, the calf may become disturbed, thus exacerbating the problem and other changes in behaviour and physiology will be employed. Responses to a temperature that is too low will also involve location change if possible.

7.2.12.2. *Body position*

Over-heated, or potentially over-heated, calves adopt positions that maximise the surface area from which heat can be lost. Such positions often involve stretching out the legs laterally if lying and avoiding contact with other calves and with insulating materials. If too cold, calves fold the legs and lie in a posture that minimises surface area.

7.2.12.3. *Water drinking*

Over-heated calves will attempt to drink in order to increase the efficiency of methods of cooling themselves.

7.2.13. To avoid harmful chemical agents

Calves need to avoid ingesting toxic substances and to react appropriately if harmful chemical agents are detected within their bodies.

7.2.14. To avoid pain

Calves need to avoid any environmental impact or pathological condition that causes pain.

8. System description

The text in this section refers to current situation in EU countries. Calf housing in other countries may be different.

8.1. Replacement dairy calves

8.1.1. Diet

Brief description of the diet of replacement heifer calves. This has not really changed since the 1995 Report. Following birth, calves receive (or should receive) colostrum and are than reared with whole milk or milk replacer. Calves are weaned; weaning ages and weaning strategies may differ according to region or country. Briefly mention current weaning strategies. Calves receive starter and, for example, hay and maize silage to promote rumen development.

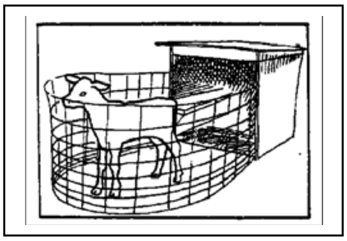
8.1.2. Housing

According to the latest EU regulation on the housing of calves (Council Directive EU 97/2/EC), group housing is compulsory for calves older than 8 weeks, unless there is any need for isolation certified by a veterinarian. Individual housing of rearing calves younger than 8 weeks, is quite common in the European dairy industry. Below, the most important housing systems for replacement heifer calves are briefly listed.

8.1.2.1. *Hutches: partially closed, outside area*

Hutches are made of plywood, plastic or fibre glass. If hutches are made from a synthetic opaque material, this prevents the greenhouse effect inside the hutch and reduces heat stress. If reflective material is used (light coloured), the sun rays are reflected which reduces the risk for overheating. The size of hutches may vary from 1.2-1.5 m width and 2.0-2.4 m length. A layer of sand, e.g. 15 cm gravel or crushed stone can be placed under the calf hutch. Litter may be provided preferably as straw, as it provides the warmest surface temperature (Panivivat et al., 2004), but also wood shavings, sawdust or newspapers are used and the layer should be thick enough to provide a comfortable and dry bed.

Calf hutches provide three different environments, as the inside is dry and protected from the weather and outside the calf is able to get limited exercise and sunlight. The calf can be also position itself half in and half out, getting sunlight and being protected from wind.



Hutches should be placed where they catch the most sunlight and avoiding hot, windy and wet locations. Nevertheless, during hot summer conditions hutches should be placed in a shady area to avoid overheating. In the rear wall, a hole that can be closed provides better air ventilation within the hut in warm weather. In the hutches, the calf can be kept using wire panels in a building with an outdoor run, preferably of more than 2.0 m^2, enabling some contact to other calves. Calves can also be fed outside using a milk bucket support, a dry feed recipient support and a hay rack. Other hutch types locate feed and water pails inside the hutch.

8.1.2.2. *Individual pens: open front structure*

Individual pens are situated in a roofed building. The area should be well-ventilated so that the air is dry and fresh, but draught has to be avoided. Separation from adult cows is advantageous with respect to disease prevention. Pens are either made from hard material with concrete walls or dismountable with three solid sides (i.e. plywood) and an open front (see Figure 1). Walls have to be perforated according to Council Directive EU 97/2/EC in holdings with more than five calves, which allow at least limited social contact with other calves, one of the key needs of calves. The open front gets fresh air to the calf and makes them easier to feed through a bucket support provided on the front. Hardwood is normally used for the floor, which is covered with a litter that is thick enough, dry and clean. Totally slatted floors are in use also, made of wood, plastic or metal, but require more care for air temperature. The 0.90 - 1.00 m x 1.50 - 1.60 m pen can be put 300 mm above the ground allowing for draining and the removal of urine.

Dismountable individual pens should be designed in such a way that they can be taken apart and stored when they are not needed, and also easily cleaned with a skid-steer loader or small bucket tractor. In case of cold weather, a plywood cover can be placed over the rear portion of the pen to preserve heat produced by the calf. In hot weather, a removable panel at the rear of the shelter can be opened to provide additional air exchange.

8.1.2.3. *Collective hutches placed in outside area*

Collective hutches may house a group of between 2 and 6 calves. The hutches are made of synthetic materials or wood. The inside of the hutch is provided with litter and some hay may be put in a rack. Roughage is distributed at a feeding barrier and anti-freeze drinking devices are needed if freezing temperatures may occur. With collective hutches fastened on concrete, a good outdoor run has a non-slippery surface. Manure and bedding have to be removed manually or the collective hutch has to move over a few metres distance by means of a tractor and guide-blocks. As for the individual hutches, the location has to be chosen carefully to avoid overheating during summer and provide protection from wind and rain entering the hutch during cold seasons, but give as much sunlight as possible.

8.1.2.4. *Straw yard with bedded lying area*

When sufficient straw and proper ventilation is provided these are the most suitable facilities for young replacement heifer calves. If the calves stay there for several months it is necessary to provide a passage on slippery free concrete. If the floor of this passage is quite rough this will prevent slipping. The concrete floor may be replaced by a slatted floor provided that the spacing between slats agrees with the age of the animals.

The lying area can be built in different ways and littered with different materials. In the deep litter system, the dung is removed at regular intervals from every few weeks to twice per year.

8.1.2.5. *Group pens inside*

Another common system for group housing of replacement heifer calves is group housing inside, in straw littered pens usually with 4-6 calves per pen. Calves may enter such group housing already after 2 weeks of individual housing.

8.1.2.6. *Group pens with automatic milk feeder*

The regulatory change with regard to calf housing together with a general trend towards larger dairy farms has increased the interest in group housing systems for rearing calves during the milk feeding period (Hepola, 2003; Jensen, 2003). In addition to systems with small groups of calves (4-6 animals per group) kept on straw and usually bucket-fed, calves are increasingly kept in larger groups (10 up to about 40 calves) with computer-controlled automatic milk feeders. An automatic milk feeder may contain two milking dispensers, and each milking dispenser can be used for about 30 calves.

To prevent hierarchic and health problems within the group, calves are grouped with a limited age difference between the animals. Calves receive milk replacer according to their needs or ad libitum. When calves are fed according to their needs, a radio-frequency electronic identifier can be used, with a transponder inserted in the collar, in an ear tag, injected under the skin or inside a ruminal bolus swallowed by the animal.

8.2. Veal calves

8.2.1. Diet

8.2.1.1. *White veal*

The diet of the vast majority of veal calves in the European Union is determined by the market demand for “white meat”, i.e. meat with low myoglobin content. The production of white veal meat comes from a tradition of fattening calves thanks to a diet based on milk, which is naturally poor in iron, and slaughtering the animals when they are young. Nowadays most veal calves are fed milk replacers that contains a variable proportion of milk powder and which iron content is maintained at a low level. This results in relatively low blood haemoglobin levels. An average blood haemoglobin level at slaughter between 4.5 and 5.0 mmol/l is compatible with an acceptable meat colour. As haemoglobin levels increase, the number of animals whose meat is darker in colour increases. In order to prevent calves from having haemoglobin levels that are too low, early in the production phase, the iron supply in the milk replacer fed during the first 7-8 weeks of the fattening period (starter) is usually about 50 ppm, whereas iron supply in the milk replacer fed during the remainder of the fattening period (fattener) is 10 ppm. Moreover, blood haemoglobin levels are generally monitored, most intensively upon arrival at the fattening unit, and calves with levels below age-dependent thresholds are treated with iron, either individually or group-wise. Thus, blood haemoglobin levels usually gradually decline across the fattening period, and the lowest average levels are supposed to be reached during the last four weeks prior to slaughter.

Some veal calves are still fed raw milk. In case of dairy breeds, the cows are generally milked and the milk is given to calves in buckets. In case of beef breeds, the calves are led twice a day for suckling their dam or another cow.

According to the latest amendment to the annex of Council Directive 91/629/EEC (Commission Decision 97/182/EC) calves should receive sufficient iron to ensure an average blood haemoglobin of at least 4.5 mmol/l, and calves over two weeks old should be provided daily with some fibrous feed which should increase from 50 to a minimum of 250 grams per day from the beginning to the end of the fattening period.

The main types of solid feed given to veal calves differ somewhat between the veal producing countries in Europe. In France and Italy solid feeds for veal calves usually consist of chopped straw or pelleted dry feed consisting of both fibrous (e.g. straw) and concentrate-like (e.g. cereal) materials. In the Netherlands, maize silage is a popular roughage source for white veal calves, provided that the iron content is not too high (an upper limit of 110-120 pp/kg dry matter is generally imposed). Maize silage is usually fed in relatively high amounts, with maximum daily amounts of up to 1.5 kg (500 gr dry matter)/calf/day. Other feeds used in the veal industry include chopped straw and rolled barley.

White veal calves are fattened for approximately 26 weeks in Italy and the Netherlands, and for 20-22 weeks in France.

8.2.1.2. *Pink veal*

Besides the production of white veal meat, several systems exist across Europe that lead to the production of so-called "pink veal meat". The main differences from the more conventional production of white veal are that the calves are reared for a longer period and they receive higher amounts of solid foods. As a consequence the muscles have a higher content of myoglobin, hence the darker colour of the meat.

In France, the calves are most often from suckler beef breeds; they are reared with their dam and may be weaned before the end of rearing.

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 a diet of ad lib 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.

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 to distinguish them from white veal meat.

8.2.2. Housing

In line with the latest EU regulation (Council Directive EU 97/2/EC), individual housing of veal calves has been officially abolished in the European Union. Already in the 1980s extensive studies were initiated with the aim to develop a practically feasible husbandry system for group housing of veal calves. At present the systems involve both large and smaller groups. Housing of calves is in groups of 2-7 animals, with a slight trend towards larger group sizes (12-20 calves per group).

8.2.2.1. *Smaller groups*

The floor can be bedded with straw or wood shavings but is more commonly made of wooden slats. Wooden slats require less labour and straw or woodshavings easily become dirty and wet. Calves are kept in individual pens, sometimes called "baby-boxes" for a period of 6-8 weeks upon arrival at the fattening unit to prevent overt preputial sucking thereafter and to be able to monitor more closely the health of calves. Baby boxes are usually made of galvanised or wooden partitions placed inside the group pen. In these boxes, calves are bucket-fed individually. After 6-8 weeks, these temporary partitions are removed and calves are free to move around in the pen. Calves are fed milk replacer in a trough or in individual buckets. A crucial management procedure associated with trough feeding is the regular re-grouping of calves, to maintain homogeneous groups in terms of calf weight and particularly drinking speed throughout fattening. Experimental work confirmed the feasibility of this procedure in that calves could be repeatedly regrouped without effects on their health, growth rate and a number of physiological measures of stress (Veissier et al., 2001). In this latter study, aggression between calves was rare, and calves seemed to habituate to repeated mixing.

Individual calves not thriving on milk replacer because of drinking problems, are provided with floating teats or with a teat-bucket.

Veal calves are sometimes kept in pairs. This type of housing results in less availability of space for movement and social opportunities than in larger groups of calves but is reported to have no disadvantages in health, weight gain and the occurrence of cross-sucking (Chua et al., 2002). Suckling veal calves are generally accomodated in small groups.

8.2.2.2. *Larger Groups*

As in the rearing of dairy calves, automatic feeding systems have been extended to veal production systems, particularly since increasingly sophisticated computer technology is becoming available for sensor-aided recognition of individual animals, and to control feeding times and intake. Calves are usually housed in large groups (40-80 calves) and receive milk replacer via an automatic feeding machine. With such feeders, calves suck to obtain their milk.

The floor generally consists of wooden slats, or concrete in combination with wooden slats. Some veal calves are kept on straw bedded floors, or have access to rubber mats or concrete covered by rubber.

8.3. Calf rearing and animal environmental pollution

8.3.1. General Introduction

In the 1995 Report there was a short chapter on calf production and environmental pollution referring to gases (ammonia, nitrous oxide, carbon dioxide). Manure resulting from calf production was seen as a fertiliser only. This chapter briefly describes in a condensed way the impact of modern animal calf production affects the environment of the animals.

Modern animal production is a source of solid, liquid and gaseous emissions which i.a. can be harmful to the animals. Solid and liquid manure and waste water contain nitrogen and phophorus which are the most important plant nutrients, but are harmful when applied to agricultural land in excess amounts thereby leading to pollution of ground water by nitrates, surface water with phosphorous causing eutrophication and soil with heavy metals such as zinc and copper which are used as growth promotors in the feed stuff, all of which can affect the animals if returned to them. A third group of potentially hazardous effluents are drug residues, such as antibiotics, which may be present in the excreta of farm animals after medical treatment and which are passed to the environment during grazing or spreading of animal manure where they may conceivably contribute to the formation of antibiotic resistance in certain strains of bacteria. The same risk arises when sludge and waste water from sewage plants containing residues of antibiotics and other drugs from human consumption are discharged as fertiliser in the soil and water body of agricultural land.

The most important aerial pollutants from calf rearing systems are odours, some gases, dust, micro-organisms and endotoxins, together also addressed as bioaerosols (Seedorf and Hartung, 2002), which are emitted by way of the exhaust air into the environment from buildings and during manure storage, handling and disposal. Aerial pollutants can give cause for concern for several reasons. E.g. an animal's respiratory health may be compromised by these pollutants. In fattening units, up to 100 % of all calves may show signs of pneumonia, pleuritis or other respiratory disease within the first three weeks of housing when the calves come together from different herds (see chapter on temperature, ventilation and air hygiene). The travel distance of viable bacteria from animal houses via the air is presently estimated at 250 m (Müller and Wieser, 1987) downwind why there is a possible transmission between animal houses. Very little is known about the distribution characteristics of dust particles, endotoxins, fungi and their spores, in the air surrounding animal houses. Recent investigations showed dispersion of *staphylococcae sp.* (bioaerosols) up to 500 m (Schulz et al., 2004) from a broiler barn. The contribution of calf production is presently unknown.

8.3.2. The quantitative share of calf production in the pollution problem

8.3.2.1. *Liquid and solid effluents*

In cattle and dairy production large amounts of faeces and urine are released by the animals which form solid and liquid manure and slurry.

It is estimated that calves produce about 5.3 kg fresh manure and 7.5 kg slurry per animal and day. This is a share of 4.6 % in the total amount of fresh manure produced in cattle farming (Richter et al., 1992).

Manure suspected to contain pathogens such as Salmonella should be stored for at least 4 months without adding or removing material and subsequently applied to arable land where it is ploughed in, or it is disinfected before any further use.

8.3.2.2. *Airborne effluents*

The second area of concern is the emission compounds such as gases, odours, dust, micro-organisms and other compounds like endotoxins which are regularly present in calf house air where they can cause or exacerbate respiratory disorders in animal and work force. The quantities emitted from calf houses are summarised in Table 8.1.

Table 8.1. Emission rates from calf houses with litter and with slats

Compounds	Calves on litter	Calves on slats
	mg/h/500 kg LW	mg/h/500 kg LW
Inhalable dust[1]	64 – 190	63 – 192
Respirable dust	14 – 40	17 – 22
Ammonia[2]	315 – 1037	1148 - 1797
Endotoxin in inhalable dust[3]	21.4 (mean) µg/h/500 kg LW, both types of houses	
Endotoxin in respirable dust[3]	2.7 (mean) µg/h/500 kg LW, both types of houses	
Total bacteria count[3]	7.2 log cfu/h/500 kg LW	
Total fungi count[3]	6.4 log cfu/h/500 kg LW	

[1]Takai et al. (1998), [2]Groot Koerkamp et al. (1998), [3]Seedorf et al. (1998b)

There are considerable emission amounts from calf husbandry. The emissions of micro-organisms are higher than from dairy or beef barns but distinctly lower than from pig or poultry production (Seedorf et al., 1998a). The same is true for endotoxins which are one log lower in cow barns but distinctly higher in pig and poultry houses. The dust emissions can be 10 times higher in piggeries and 100 times higher in broiler barns (Takai et al., 1998). The ammonia concentration is usually lower than in piggeries or laying hen houses. However this depends greatly on the housing and manure management system. In a US study Johnson et al. (2001) reported that cow-calf, stocker and feedlot phases contribute considerable amounts of nitrous oxide and methane to the emissions from cattle production.

9. Comparison of systems and factors

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

9.1.1. Feeding systems

The main potential problems associated with the housing of calves in large groups with automatic feeders include: cross sucking, i.e., non-nutritive sucking of parts of another calf's body (in particular the ears, mouth, navel, udder-base and, in case of bull calves, the scrotum and prepuce) (Plath et al., 1998; Bokkers and Koene, 2001; Jensen, 2003), competition for access to the feeder (Jensen, 2003; 2004), and health problems, in particular a high incidence of respiratory disease (Maatje et al., 1993; Plath et al., 1998; Svensson et al., 2000, 2003; Hepola, 2003; Engelbrecht Pedersen et al., 2005).

A number of factors have been identified that are likely associated with some of these problems, although conflicting results have been reported. Cross-sucking is linked with the sucking motivation of calves and, hence, measures to reduce the motivation of calves for non-nutritive sucking may reduce the occurrence of cross-sucking (De Passillé, 2001). An increased milk allowance also reduced non-nutritive sucking on a teat as well as cross-sucking in group-housed calves in one experiment (Jung and Lidfors, 2001), but did not affect cross-sucking in another (Jensen and Holm, 2003). Reducing the milk flow rate decreased non-nutritive sucking on a teat in individually housed calves (Haley et al., 1998), but failed to influence cross-sucking in group-housed ones (Jung and Lidfors, 2001; Jensen and Holm, 2003). Alternatively, it has been suggested that hunger may also control the level of non-nutritive sucking and possibly cross-sucking (Jensen, 2003). This idea is consistent with the observations that the duration of unrewarded visits to an automatic feeding station increased during gradual weaning (Jensen and Holm, 2003), and that under practical farm conditions the frequency of cross-sucking among dairy calves around weaning is increased with decreasing availability or energy density of solid feeds (Keil et al., 2000; Keil and Langhans, 2001).

In contrast to other calves, white veal calves are not weaned, receive large amounts of milk replacer and usually obtain only restricted amounts of solid food. These additional factors may also affect and perhaps exacerbate cross-sucking in systems with an automatic feeder (Jensen, 2003). Results by Veissier et al. (2002) showing that bucket-fed group-housed veal calves show less cross-sucking than those fed by an automatic feeder again seem to implicate factors other than sucking motivation *per se* in the development and expression of cross-sucking. On the other hand, rearing calves in large groups with an automatic feeder allows more interactions between calves and offers calves the possibility to suck milk.

Competition for access to an automatic milk feeder was increased in groups of 16 or 24 calves in comparison with groups of 8 or 12, respectively (Herrmann and Knierim, 1999; Jensen, 2004), and under dietary conditions of relatively low milk allowance and reduced milk flow rate (Jensen and Holm, 2003). Protecting calves from displacement at the feeder may also be accomplished by fitting a closed feeding stall to the station (Weber and Wechsler, 2001). In comparison with the usual setup, this modification increased the duration of visits to the feeder as well as the duration of non-nutritive sucking on the teat after milk ingestion, and significantly reduced the frequency of cross-sucking within 15 minutes after milk ingestion. However, the incidence of cross-sucking performed without prior milk ingestion was not affected by the design of the feeder (Weber and Wechsler, 2001).

In a recent comprehensive review, Jensen (2003) observes that there is a lack of knowledge on the effect of different weaning methods on cross-sucking. She also concludes that future research should focus on preventive measures to reduce cross-sucking and problems with aggression in automatically fed calves, including the establishment of appropriate numbers of calves per feeder.

The apparent increase in health problems of calves kept in large groups with automatic feeders might be related to group size rather than to feeding system. A comparison of two different group sizes of calves fed by an automatic milk feeder showed that calves housed in groups of 12-18 had a higher incidence of respiratory illness and grew less than calves housed in groups of 6-9 (Svensson and Liberg, 2006). Similarly, placement of preweaning heifer calves in groups of 7 or more was associated with high calf mortality in a large scale epidemiological survey (Losinger and Heinrichs, 1997).

Interestingly, in a study by Kung et al. (1997), group-housed calves fed by an automatic feeding system for milk supply had fewer days of medication than those kept individually in separate calf hutches. These authors also emphasize the importance of good management and frequent observations of calves as an integral part of a successful rearing program. Likewise, Howard (2003) specifically links good and correct management practices with the prevention of disease and successful group housing of dairy calves.

9.1.2. Weaning strategies

Natural weaning in cattle takes place when young animals are around 8-9 months of age. Depending on productive system, weaning can usually occur between 1 and 10 months of age. Dairy calves are usually reared away from their dams and they are given milk or milk replacer until weaning at 6 to 8 weeks of age. However Holstein calves can be weaned at 3 to 5 weeks of age (early weaning). Beef calves are usually weaned at 6 to 10 months of age depending on season of birth. Early weaning of beef calves may be considered as a management practice in poor climate conditions and where forage quality is poor later in the grazing season. Several studies have shown that it is possible to wean calves at very young ages based on concentrate intake (SVC, 1995). However, regardless of the productive system, weaning is effective and does not cause health and welfare problems to calves when it occurs as a smooth transition from an immature to mature ruminant with an adequate size and development of the reticulo-rumen for efficient utilisation of dry and forage based diets.

At birth, the reticulum, rumen, and omasum of the calf are undeveloped, non-functional and small in size compared to the abomasum and rumen remains underdeveloped during the first 2-3 months of age. Calves being ruminant animals require a physically and functionally developed rumen to consume forages and dry feeds. However, the rumen will remain undeveloped if diet requirements for rumen development are not provided. Solid feed intake stimulates rumen microbial proliferation and production of microbial end products, volatile fatty acids, which initiate rumen epithelial development (Heinrichs and Lesmeister, 2004). Solid feeds are preferentially directed to the reticulo-rumen for digestion, however they differ in efficacy to stimulate rumen development. Recent studies have shown that addition of yeast culture (2%) increased calf grain intake, but did not affect rumen development in young calves (Lesmeister et al., 2004); while papillae length and rumen wall thickness were significantly greater in 4 week old calves fed calf starters containing steam-flaked corn over those fed dry-rolled and whole corn when these corn supplements made up 33% of the calf starter (Lesmeister and Heinrichs, 2004) showing that the type of grain processing can influence rumen development in young calves.

Forages seem to be the primary stimulators of rumen muscularization development and increased rumen volume (Zitnan et al., 1998). Large particle size, high effective fibre content, and increased bulk of forages or high fibre sources physically increase rumen wall stimulation, subsequently increasing rumen motility, muscularization, and volume (Heinrichs and Lesmeister, 2004; Coverdale et al., 2004). Besides, solid feeds other than forages or bulky feedstuffs can be effective in influencing rumen capacity and muscularization. Coarsely or moderately ground concentrate diets have been shown to increase rumen capacity and muscularization more than finely ground or pelleted concentrate diets, indicating that extent of processing and/or concentrate particle size affects the ability of concentrates to stimulate rumen capacity and muscularization (Beharka et al., 1998; Greenwood et al., 1997). Therefore, it seems that concentrate diets with increased particle size may be the most desirable feedstuff for overall rumen development, due to their ability to stimulate epithelial development, rumen capacity, and rumen muscularization (Heinrichs and Lesmeister, 2004).

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. But, as pointed out from recent research attention must paid to type of forage and consistent of particle size of starter grain in order to achieve a proper rumen development. A calf consuming 0.7 kg of dry feed or more on three consecutive days is ready for weaning. 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. Early weaning systems should not be used if the animals are in a negative energy balance.

9.1.3. Quality of solid and liquid feed

9.1.3.1. *Solid feed: concentrates and roughage*

Traditionally, veal calves were fattened on a diet consisting exclusively of milk replacer. Calves fed in this manner show a number of welfare problems (reviewed in the previous report), including abnormal behaviours and disease associated with lack of rumen development. To better safeguard the welfare of calves, provision of (some) solid feed to veal calves has become compulsory according to the latest amendment to the annex of Council Directive 91/629/EEC (Commission Decision 97/182/EC).

However, provision of roughage to veal calves fed a regular milk replacer diet, has clearly been demonstrated to increase the incidence of abomasal ulcers, in particular in the pyloric part (which connects to the duodenum) (Wensink et al., 1986; Welchman and Baust, 1987; Breukink et al., 1991). Thus, recent studies have largely focussed concurrently on the effects of provision of roughage on calf behaviour, abomasal lesions and rumen development, in an attempt to identify feeds that may benefit veal calf welfare without compromising abomasal integrity.

In a comprehensive EU-funded project, a range of different types of roughage/solid feeds (straw, maize silage, maize cob silage, rolled barley and beet pulp) in different amounts (250 versus 500 gr dry matter) and of different particle sizes and physical characteristics (i.e., chopped versus ground, dried versus fresh, un-pelleted versus pelleted) were given to veal calves in addition to milk replacer in large-scale multifactorial trials (Chain Management of Veal Calf Welfare, 2000; Cozzi et al., 2002; Mattiello et al., 2002). Control treatments consisted of milk replacer only, and milk replacer with ad lib access to hay. Another control group consisted of bull calves reared in a similar way to normal dairy calves, i.e. the animals received ad libitum hay and concentrates and were weaned at 7 weeks of age.

In comparison with milk replacer only, those types of roughage that were richest in fibrous material, i.e. straw (regardless of amount and physical structure) and hay, significantly reduced the level of abnormal oral behaviours (composed of tongue rolling, tongue playing and compulsive biting/sucking of substrates), and concomitantly increased the level of rumination. Weaned calves exhibited no abnormal oral behaviours. Higher levels of rumination in veal calves as a function of the fibre content of the solid feed were also reported by Morrisse et al. (1999, 2000). In line with these findings, Veissier et al. (1998), observed reduced levels of biting at substrate and more chewing behaviour in veal calves provided with straw compared with un-supplemented controls. Previously, it has been suggested that a sucking deficit causes abnormal oral behaviours in calves (Sambraus, 1985). More recent data, however, clearly identify the lack of appropriate roughage as a major determinant of abnormal oral behaviours in veal calves. Correspondingly, Bokkers and Koene (2001) found no differences in abnormal oral behaviours between group-housed veal calves fed either by bucket or by an automatic feeder. Results obtained in veal calves are also fully consistent with data in cows (Redbo et al., 1996; Redbo and Nordblad, 1999) and other ruminants such as giraffes (Baxter and Plowman, 2001), which all link increased levels of abnormal oral behaviours with feeds poor in fibre.

In agreement with previous data, most roughages provided to milk-fed veal calves significantly increased the incidence of abomasal lesions, particularly ulcers in the pyloric region, in comparison with the feeding condition without additional roughage (Chain Management of Veal Calf Welfare, 2000; Mattiello et al., 2002). Incidences of abomasal ulcers (expressed as the percentages of calves with one or more lesions) among weaned bull calves, calves fed milk only, and veal calves given supplemental roughages were 0, between 20-25, and between 50-80%, respectively. This suggests that the interaction between roughage and a milk replacer diet rather than roughage *per se*, is involved in the etiology of abomasal ulcers in veal calves. These findings support the hypothesis that pyloric ulcers in milk-fed veal calves may be caused by local ischaemia followed by focal necrosis as a consequence of strong contractions of the pyloric wall when large volumes of milk are consumed. Provision of roughage, in turn, would then exacerbate an existing problem in that roughage particles exert a mechanically abrasive effect on a sensitive abomasal mucosa, and delay the healing of any lesions already present (Unshelm et al., 1982; Dämmrich, 1983; Krauser, 1987; Welchman and Baust, 1987; Breukink et al., 1991). This explanation may also fit the observations that veal calves fed either hay or a combination of concentrates and straw exhibited similar incidences of abomasal ulcers to those fed milk replacer only (Chain Management of Veal Calf Welfare, 2000; Veissier et al., 1998). These roughages represent more balanced feeds, accompanied by better rumen fermentation. This may have improved ruminal digestion of fibres, thereby preventing sharp undigested particles entering the abomasum.

Other factors proposed or examined in relation to the pathogenesis of abomasal ulcers in calves include stress, infection with bacteria, trace mineral deficiencies, and prolonged periods of severe abomasal acidity (Lourens et al., 1985; Mills et al., 1990; Jelinski et al., 1995; De Groote et al., 1999; Palmer et al., 2001; Ahmed et al., 2001, 2002, 2005). However, so far none of these factors have been convincingly related to abomasal ulcers in veal calves.

Calves fed milk only, showed a high incidence of ruminal hairballs. In different experiments between 70-80% of milk-fed veal calves had hairballs (Chain Management of Veal Calf Welfare, 2000; Cozzi et al., 2002). Feeding roughage gave a profound reduction of hairballs; depending on the type of roughage the incidence varied between 0-30 %. Similarly, Morisse et al. (1999) reported a marked reduction of ruminal hairballs in calves fed pelleted straw and cereals. This reduction was thought to result from a continuous elimination of ingested hair by improved ruminal motility. However, it may well be that abnormally high self-licking behaviour is reduced when roughage is provided.

It is suggested that further optimising the composition of roughage in terms of adequate rumen development and rumen function, may eventually result in feeds that promote rumination and reduce abnormal oral behaviours without damaging the digestive apparatus (Chain Management of Veal Calf Welfare, 2000; Morisse, 2000; Mattiello et al., 2002)

9.1.3.2. *Composition and quality of liquid feed*

For all newborn calves, receiving an adequate amount of high quality colostrum is essential for their health and survival. In comparison with mature milk, colostrum contains greater concentrations of total solids and of fat, protein, vitamins and minerals. Most importantly, colostrum provides the calf with immunoglobulins (IgG), which are vital for its early immune protection. In addition, colostrum contains a range of other non-nutrient and bioactive components including various types of cells, peptide hormones, hormone releasing factors, growth factors, cytokines and other bioactive peptides, oligosaccharides and steroid hormones. These factors modulate the microbial population in the gastrointestinal tract, have profound effects on the gastrointestinal tract itself (e.g. cell proliferation, migration, differentiation; protein synthesis and degredation; digestion, absorption, motility; immune system development and function), and in part exert systemic effects outside the gastrointestinal tract on metabolism and endocrine systems, vascular tone and hemostasis, activity and behaviour, and systemic growth (Waterman, 1998; Blum, 2006).

The highest quality colostrum, or true colostrum, is obtained from the very first milking after parturition. Thus, provision of first colostrum to newborn calves is one critical factor for successful calf rearing. The timing of provision of colostrum is also crucial since the ability of the calf's small intestine to absorb large proteins such as IgG decreases rapidly following birth. Consumption of sufficient colostrum within the first 24 h of life is needed not only for an adequate immune status but also to produce the additional important and favourable effects on metabolic and endocrine traits, and on vitality. Finally, colostrum should be regularly provided for a sufficient length of time, preferably for the first three days after birth (Hadorn et al., 1997; Waterman et al., 1998; Rauprich et al, 2000).

Although the importance of colostrum for calf health and survival is generally recognized, actual practices in calf rearing do not always favour adequate colostrum intake in newborn calves, and may therefore pose a risk for their welfare.

After the period of colostrum feeding, calves can be switched to whole milk or a high quality milk replacer. In the case of rearing calves, both sources of liquid feed are used, although the majority of dairy calves are currently reared on a milk replacer diet. Milk replacers are usually less costly than saleable whole milk, and the feeding of raw waste milk may pose several health and contamination risks, including the transfer of infectious diseases to the calf, and problems with antibiotic residues or overdoses (Wray et al., 1990; Selim and Cullor, 1997; Waltz et al., 1997). At present, good quality milk replacers may provide comparable performance to whole milk. However, pasteurization of waste milk prior to feeding it to calves may also represent an effective and viable alternative for minimizing health risks (Stabel et al., 2004). Results from a recent clinical survey by Godden et al. (2005) even suggested that dairy calves fed pasteurized waste milk have a higher growth rate and lower morbidity and mortality rates than do calves fed conventional milk replacer.

With the exception of production systems involving suckler cows, veal calves are generally fattened on milk replacer diets. Over time, formulations of commercially available milk replacers for veal calves (as well as those for dairy calves) have become more and more sophisticated. At the same time, economic pressures continuously prompt the industry to reduce feeding costs and to consider alternative components and raw materials. Originally, proteins in milk replacers were milk-based, and skim milk powder constituted the major protein source. Subsequently, milk replacers based on whey powder became available. Approximately during the last two decades, attempts have been made to replace animal-based proteins in milk replacers by vegetable proteins, mainly from soybean and wheat and, to a lesser extent, pea and potato. Initially, some of these attempts met with little success because of health problems in the calves. For example, compared to calves fed diets based on skim milk powder, calves fed milk replacers containing heated soybean flour developed severe immune-mediated gut hypersensitivity reactions characterized by partial atrophy of the small intestinal villi, malabsorption, diarrhoea, and large infiltrations of the small intestine by immune cells, accompanied by the presence of high antibody titres against soy antigens in plasma and intestinal mucous secretions (Lalles et al., 1995a, 1995b, 1996, 1998; Dreau et al., 1995; Dreau and Lalles, 1999). However, the nutritional utilization of vegetable proteins can be improved by a variety of technological treatments including, for example, heating, protein hydrolysis, and ethanol extraction. Such treatments reduce anti-nutritional factors and antigenic activity, and increase protein digestibility by denaturing three-dimensional structures (Lalles et al., 1995c, 1995d). At present a number of processed plant proteins are successfully applied in combination with milk-based protein sources in milk replacers for (veal) calves, including hydrolysed soy protein isolate and hydrolysed wheat gluten. Recent research in the area of plant proteins in milk replacer formulas is focussed on understanding mechanisms underlying the flow of proteins in duodenal digesta, and the interaction of dietary peptides with the gut, in particular at the level of the mucus layer (Montagne et al., 2001, 2003, 2004). Results of this type of work may further enhance the use of plant proteins in milk replacers for calves.

In addition to an enhanced risk for gut problems, low quality milk replacers may also cause dysfunction of the oesophageal groove reflex, which may result in ruminal acidosis. In this respect, temperature is also an important quality feature; a too cold drinking temperature of the milk replacer attenuates the oesophageal groove reflex (Gentile, 2004).

If vegetable proteins are not properly treated, milk replacers may cause hypersensitivity reactions in the gut, which may compromise calf welfare.

9.1.4. Dietary iron and anaemia

Low iron dietary supply is a prerequisite for the production of white veal. The blood haemoglobin level in veal calves towards the end of fattening (between 4.5 and 5.0 mmol/l), is generally considered a threshold below which iron deficiency anaemia occurs (Bremner, 1976; Van Hellemond and Sprietsma, 1979a, 1979b; Postema, 1985; Lindt and Blum, 1994a), although some authors have argued that this level is already below a critical value (Welchman et al., 1988). When calves were forced to walk on a treadmill, those with a mean haemoglobin level of 5.5 mmol/l consumed more oxygen and exhibited higher cortisol levels after walking than calves whose haemoglobin level was 6.6. or 6.9 mmol/l (Piguet et al., 1993). On the other hand, blood lactate after transport was not significantly different between groups of calves with average haemoglobin levels of 4.6 and 6.6. mmol/l, respectively (Lindt and Blum, 1994b).

There is a large body of evidence showing that iron deficiency anaemia may compromise immunocompetence, in particular cellular immune function, in a range of species including laboratory rodents and humans (Dallman, 1987; Dhur et al., 1989; Galan et al., 1992; Latunde-Dada and Young, 1992; Ahluwalia et al., 2004). In human children, iron-deficiency states have been epidemiologically associated with increased morbidity due to respiratory infection and diarrhoea (Keusch, 1991; De Silva et al., 2003; Levy et al., 2005). This justifies the question of whether dietary iron supply and associated haemoglobin levels are sufficient to guarantee adequate health in white veal calves. Previous results concerning the relationship between clinical health and anaemia in veal calves are scarce, and were inconclusive.

Using very small numbers of calves, Möllerberg and Moreno-Lopez (1975) found no difference between iron anaemic and normal calves in the clinical response to infection with an attenuated parainfluenza-3 virus strain, whereas Sárközy et al. (1985) reported a depressed immune response as reflected in significantly lower antibody levels in anaemic calves compared with controls following inoculation with a live adenovirus.

In a study by Gygax et al. (1993), cellular immune function was depressed, and disease incidence, especially of respiratory infections, was increased in calves fed low amounts of iron. However, in this particular study, haemoglobin levels dropped considerably below the value of 4.5 mmol/l.

A more recent study (Van Reenen et al., 1999), therefore, aimed to examine immunocompetence in a bovine herpes viral (BHV1) infection model in white veal calves with blood haemoglobin levels maintained at all times above or just at 4.5 mmol/l. Calves daily supplemented with extra iron exhibited normal haemoglobin levels across the entire experiment (average approximately 7.5 mmol/l), whereas white veal calves had average haemoglobin levels at the time of BHV1 infection and at slaughter of approximately 5.3 and 4.9 mmol/l, respectively. Dietary iron supply did not affect the reactions of calves to BHV1 infection (clinical signs, viral excretion in nasal fluid, antibody reponse), white blood cell and lymphocyte counts, and growth rate. By contrast, in comparison with calves with high haemoglobin levels, white veal calves exhibited a higher heart rate during milk intake, had consistently elevated levels of urinary noradrenaline, and showed enhanced plasma ACTH and reduced plasma cortisol responses in a number of HPA axis reactivity tests. These latter findings concur with increased heart rate and catecholamines in urine, and altered responsiveness of the HPA axis in iron-deficient or anaemic humans and laboratory rodents (Voorhess et al., 1975; Dillman et al., 1979; Dallman et al., 1984; Groeneveld et al., 1985; Saad et al., 1991). These physiological changes are part of an elaborate adaptive response to iron deficiency (Beard, 1990; Rosenzweig and Volpe, 1999), which also involves alterations in glucose metabolism (Blum and Hammon, 1999).

Veal calves with blood haemoglobin levels clearly below 4.5 mmol/l demonstrated reduced growth rates as well as a large depression in white blood cell and lymphocyte counts (Reece and Hotchkiss, 1987; Gygax et al., 1993). Thus, it is suggested that maintaining blood haemoglobin in individual veal calves over 4.5 mmol/l induces a number of physiological adaptations which seem universal for iron-deficient mammals in general, but do not harmfully compromise biological capacities in terms of growth and immunocompetence.

In actual practice, however, the haemoglobin threshold of 4.5 mmol/l is currently considered at the group rather than at the individual level. For example, an average haemoglobin level of 4.5 mmol in a group of finished veal calves is assumed to be exactly at the lower threshold value. However, depending on the variation between individuals, if a group of calves has an average haemoglobin level of 4.5 mmol/l, then some individuals within that group may have levels well below this lower threshold value. In fact, based on an analysis of the variation between calves in blood haemoglobin levels, it has been argued that the haemoglobin threshold for anaemia of a group of veal calves should be higher than that of an individual calf, i.e. an average level of 6.25 rather than 5 mmol/l (Van Hellemond and Sprietsma, 1979a).

In order to prevent anaemia during fattening, blood haemoglobin levels are monitored to some extent in white veal calves, and animals are treated with supplemental iron according to age-dependent haemoglobin thresholds. However, systematic monitoring generally occurs only on two occasions: within the first 2-3 weeks upon arrival at the fattening unit, in all animals, and between 12-14 weeks of fattening, in a sample of calves. Outside these instants, individual calves may receive iron supplementation in the presence of clinical signs of iron deficiency. But once clinical signs are apparent, haemoglobin levels are usually well below 4.5 mmol l^{-1} (Blaxter et al., 1957; Bremner et al., 1976).

Since blood haemoglobin levels are not routinely monitored in veal calves beyond the 14th week of fattening, there is a likelihood of too low haemoglobin levels occurring in part of the animals, in particular towards the end of fattening, when low haemoglobin levels are most likely to occur.

9.2. General housing

Calves kept indoors are housed in an environment where several important factors interact such as space, pen design, social contacts, flooring and bedding material as well as climate. In experimental studies, usually one or a few of these factors are varied and the others controlled for. However in larger epidemiological studies many of these factors vary and their interaction can be measured. In a study of 3081 heifer calves in 122 Swedish dairy herds the effect of draught, cleanliness of the animals, hygiene level of the farm, placing of the calf pens, nature of the pen walls, air volume per animal, management factors such as status of the caretaker and feeding routines was evaluated by means of a two-level variance component logistic model. The placing of calf pens along an outer wall was significantly associated with the risk of diarrhoea (odds ratio (OR): 1.92, $p<0.01$), the risk for respiratory disease was significantly associated with an ammonia concentration below 6 ppm (OR: 0.42, $p<0.05$) while the OR for moderately to severely increased respiratory sounds was significantly associated with draught (OR: 3.7, $p<0.02$) (Lundborg et al., 2005). Odds ratios for respiratory disease were increased in calves housed in large-group pens with an automatic milk-feeding system (OR: 2,2) (Svensson et al., 2003).

9.3. Space and pen design

The 1995 report highlights that the housing systems of calves and the available space affect the development and determine which behaviours the animals are able to perform. The 1995 report (SVC, 1995) recommends the minimum space for both single crate and group pen and it points out how lack of space can affect health and welfare of reared calves (Maatje and Verhoeff, 1991; Dantzer et al., 1983; Friend et al., 1985). The 1995 report also suggests that shape of the pen can be important to the animal.

9.3.1. Recent findings regarding importance of space

Recent studies confirmed that the space available can affect both behavioural and physiological traits and productive performances of cattle. However, the majority of them compare behaviour, production or other indicators of calves reared in individual crates versus group pens (Vessier et al., 1998; Andrighetto et al., 1999; Jensen, 1999; Verga et al., 2000; Cozzi et al., 2000; Bokkers and Koene, 2001) or tethered or single pen (Terosky et al., 1997; Wilson et al., 1999) which were already discussed in chapter 8. Little research has been done to directly compare behavioural and physiological indicators of welfare in calves reared in pens of various space allowances. In dairy calves it has been shown that spatial environment stimulated play: calves in small group pens performed less locomotory play that the ones kept in larger pens (Jensen et al., 1998; Jensen and Kyhn, 2000). It has been reported in a preliminary study that dairy calves kept, from birth to 1 month of life in larger stalls (1.00 m X 1.50 m) showed a higher percentage of lying behaviour and grooming than calves kept in smaller stalls (0.73 m X 1.21 m); besides, lymphocyte proliferation was significantly higher in calves reared in large stalls (Ferrante el al., 1998).

9.3.2. Recent findings regarding importance of pen design

It is known that cattle prefer to use the perimeter of pens rather than the central area (Stricklin et al., 1979; Hinch et al., 1982; Fraser and Broom, 1997). The ratio between the number of corners in the pen and number of animals seems to influence the individual space, the space that calves try to keep to other calves, as showed by simulation models (Stricklin et al., 1995). Therefore pen shapes maximising the perimeter to area ratio might be preferable for cattle (Jóhannesson and Sørensen, 2000). For this reason it has been pointed out that measurements such as pen perimeter, the number of corners and the diagonal distance of the pen could be important for dairy cattle (Jóhannesson and Sørensen, 2000). However there is a lack of knowledge on this topic on calves. In a study on veal calves most of the animals lying next to the wall, the quieter and drier part of the pen, stood more on the side of the far pen and eliminated in the feeding area (Stefanowska et al., 2002). Calves kept in a large group (26 animals) and fed using an automatic milk replacer showed an elevated use of the area around the partition of the pen and they spent little time in the centre of the area. (Morita et al., 1999), this use of the pen space could lead to a pen design functionally divided into a walking and feeding area and a lying area.

9.4. Flooring and bedding material

The 1995 report concludes that slatted floors must not be slippery, it also recommends appropriate bedding, for example straw, and that every calf should have access to a dry lying area. The report highlights that housing and management conditions can affect the posture adopted when lying and resting in calves.

9.4.1. Recent findings regarding importance of floor and bedding materials

Slatted floors have been used for many years as convenient for intensive housing for beef cattle but concerns have been expressed about their effects on animal welfare (SCAHAW, 2001). The type of surface not only affects the movements of getting up and lying down, lying and resting behaviour of the fattening animals but also other behavioural traits and physiological indicators of stress (SCAHAW, 2001). Moreover when cattle can choose between different floor types they prefer deep litter to slatted floor especially for resting.
Many studies were conducted in order to analyse the floor comfort in the lying area in dairy and in beef cattle (for a list of references see Tuyttens, 2005; SCAHAW, 2001). The group pens for veal calves do not have separate lying areas and therefore the animals spend all their time on the same surface. If the floor is too hard for lying or too slippery, discomfort, distress and injury may result. A suitable floor is very important for calves as adequate rest is essential for the good welfare of young growing animals, moreover a positive correlation between the amount of rest and growth rates has been observed for growing cattle (Mogensen et al., 1997; Hanninen et al., 2005). Adequate resting is important both for sleep and temperature regulation. Veal calves are often housed on slatted floors, commonly made of hardwood, a product that is controversial because it often comes from unsustainable forestry in tropical countries (Stefanowska et al., 2002), or on concrete floors due to the fact that bedding material is costly and requires more labour and can cause problems in manure handling systems. Wooden slatted floors can absorb liquid from manure and a wet surface is not comfortable for moving and lying (Verga et al., 1985). Even if straw bedding provides better floor comfort to animals than slatted or concrete floors, suitable alternatives to reduce or eliminate the use of straw bedding are available for cattle (Tuyttens, 2005). Recent studies have investigated the effect of the texture (how soft) and the thermal properties of floor on lying postures and resting behaviour of calves. In cool or drafty floors calves spent less time resting on the side and rest curled up in order to conserve heat (Hanninen et al., 2003). In contrast with adult dairy cows which rested longer and lay down more frequently on softer floors, there was no effect of type of floor (concrete floor or rubber mats) on resting behaviour of dairy calves (Hanninen et al., 2005). In another experiment where veal calves could choose to use a hardwood slatted floor surface or a synthetic rubber coated floor surface the calves preferred the wooden floor for lying (Stefanowska et al., 2002). Moreover the animals rested in the drier part of the pen (Stefanowska et al., 2002). From these studies it seems that the texture of the floor is not as important to calves as to older animals, whereas thermal comfort seems to affect lying and lying postures. Panivivat et al. (2004) investigated growth performance and health of 60 dairy calves bedded with five different types of materials (granite fines, sand, rice

hulls, long wheat straw, wood shavings) for 42 days during August to October from birth. Overall average daily gain and dry matter intake of calves did not differ with bedding type, although during week 2, calves housed on rice hulls had the greatest dry matter intake and those housed on wood shavings had the lowest. During week 2, calves housed on granite fines and sand were treated more often for scours, and calves housed on long wheat straw received the fewest antibiotic treatments (week by bedding material interaction). Granite fines formed a harder surface than other bedding, and calves housed on granite fines scored the dirtiest. Long wheat straw had the warmest surface temperature, and rice hulls and wood shavings were warmer than granite fines and sand. Serum cortisol, alpha (1)-acid glycoprotein, immunoglobulin G concentrations, and the neutrophil:lymphocyte ratio were not affected by bedding type. On day 0, coliform counts were greatest in rice hulls. After use, coliform counts were greatest in long wheat straw (week by bedding material interaction). Growth rates of calves bedded for 42 d with 5 bedding types did not differ; however, the number of antibiotic treatments given for scours was greatest on granite fines and sand; coliform counts in the bedding were highest in rice hulls before use and in long wheat straw after 42 days of use.

9.5. Degree of social contact

The 1995 report recommends that calves are cared for by their dam after birth so that they are licked and receive colostrum and that calves are not deprived of social contact, especially with other calves because 1) calves for social contacts; 2) calves isolated from other calves express more abnormal activities (e.g. excessive grooming, tongue rolling), are hyper-reactive to external stimuli and their subsequent social behaviour is impaired; and 3) in combination with restricted space or lack of straw, individual housing induces a chronic stress state as assessed through enhanced responses to an ACTH challenge.

9.5.1. Recent findings regarding contacts with the dam

The bond between dam and calf is likely to develop very soon after birth: calves separated from their dam at 24h can recognise the vocalizations of their own dam one day later (Marchant-Forde et al., 2002)

In their review about early separation between dairy cows and calves, Flower and Weary (2003) conclude that, on the one hand, behavioural reactions of cows and calves to separation increase with increased contacts but, on the other hand, health and future productivity (weight gain for the calf, milk production for the cow) are improved when the two animals have spent more time together.

Calves reared by their dam do not develop cross-sucking while artificially reared calves do so (Margerison et al., 2003). The provision of milk through a teat, a long milk meal, and the possibility to suck a dry teat can decrease non-nutritive sucking in artificially reared calves but do not abolish it (Review by Jensen, 2003; Lidfors and Isberg, 2003; Veissier et al., 2002).

The presence of adult cows other than the dam do not help calves to get accustomed to new rearing conditions, as observed by Schwartkorf-Genswein et al. (1997) for calves submitted to feedlot conditions.

9.5.2. Recent findings regarding contacts with other calves

Recent studies confirmed that calves are motivated for social contact. Such a motivation was shown using operant conditioning by Holm et al. (2002); furthermore calves that are housed individually engage in more contacts with their neighbours than calves housed in pairs (Raussi et al., 2003).

The presence of a companion can reduce emotional responses of calves. This, for instance, is the case when group housed calves are exposed to a novel situation like a novel object (Boivin et al., 1999), a novel arena (Jensen et al., 1997), a sudden event (Veissier et al., 1997), or a lorry (Lensink et al., 2001).

Humans are not a good substitute for social contacts. Individually housed calves interact more with their neighbours compared with pair-housed calves, even when they receive additional contacts from the stockperson (e.g. stroking, letting suck fingers, speaking softly) (Raussi et al., 2003). (See section on human-animal relationships).

9.5.3. Comparison between individual housing vs. group housing

Individual housing can be stressful to calves as measured by adrenal responses to ACTH (Raussi et al., 2003).

Group housed calves are generally more active than individually housed calves as far as gross activity is concerned (more time spent moving or eating, less time spent idling or lying) (Babu et al., 2004; Raussi et al., 2003).

Group housing can benefit production: Xiccato et al. (2002) found that calves housed in fours put on more weight than calves tethered in individual crates. However, this seems not to be the case when the calves are <u>not</u> tethered in individual crates (Veissier et al., 1998).

Group housed calves are less easy to handle. Human contact is thus essential for them to become accustomed to humans and to react less to handling (Lensink et al., 2001; Mogensen et al., 1999).

Group housing can help calves acquiring social skills (Boe and Faerevik, 2003). Some experience of mixing is of particular importance: calves that have been reared for a while in a group dominate calves that have always been in individual crates (Veissier et al., 1994). By contrast, it is not clear whether repeated mixing would be beneficial or harmful to calves (Boissy et al., 2001; Veissier et al., 2001).

Recent research (e.g. Svenson et al., 2003 and Svensson and Liberg, 2006) suggests that transfer from individual pen to group-housing during the second week of life is disadvantageous for health reasons (see chapter 10) and, that a delay in mixing until the calf is 2 weeks old may be preferable. Additional research seems necessary to establish what mixing age would be preferable from a health and welfare perspective.

9.6. Temperature, ventilation and air hygiene

The importance of the aerial environment inside a calf house for the health status of the animals was stressed in the 1995 Report, and it still seems to be one of the major factors which cause morbidity and mortality (Svensson et al., 2006). Bioaerosols (micro-organisms, dust), low air temperatures together with high air humidity, gases such as ammonia, draught, insufficient air space and poor ventilation form a complex environmental situation which can be detrimental particularly for the respiratory health of young calves (Lundborg et al. 2005; SVC, 1995).

9.6.1. Temperature and relative humidity

A healthy calf consuming a sufficient amount of feed has a wide zone of thermal neutrality. There is no difference in the performance of healthy, normal eating calves at temperatures ranging between 0 °C and 20 °C provided it is dry and not exposed to draughts. Above 25 °C conditions in confined calf houses can start to become uncomfortable. Moran (2002) suggests that the ideal temperature and relative humidity for calves are 17 °C and 65 %, respectively. However, there is a large number of influencing factors to consider which can alter the situation for a calf substantially. Lower critical temperatures for a calf in calm air and full feed are different whether it stands (-3 °C) or is lying on dry concrete (-6 °C) or on dry straw (-8 °C) (Thickett et al. 1990). The younger the animal the higher is its demand for the thermal environment. By 1 week of age, the lower critical temperature in still air is approximately 8 °C (Webster, 1984). This temperature can be significantly changed by draught, wet coat and feeding level. Young calves start to shiver at 8 °C when they are exposed to draught even if their coat is dry and they are fed sufficient feed. When fed on maintenance only level shivering starts at 12 °C. If their coat is wet and they are exposed to draught shivering starts at 13 °C when on full feed and 19 °C when fed on a low level (Moran, 2002). No signs of shivering are observed at 3 °C when the coat is dry with no draught and feeding is at a normal level. Cold stress in calves can be prevented by providing dry lying areas, appropriate feeding and draught free ventilation. Dry bedding such as straw significantly improves thermal comfort for the lying calf. In summer situations reduced feeding (but with sufficient water supply!) or feeding calves in the cooler evening or at a reduced animal density per pen and increased ventilation rates can help to lower heat stress. Heat stress can also be reduced through constructing sheds with insulated roofs and well ventilated walls. Calf houses with a solid wall construction and a high capacity to store energy combined with an efficient ventilation system can also contribute to create comfortable environmental temperatures for young calves kept indoors all year (DIN 18910, 2004). The preferred environmental temperature for calves is not fixed, it largely depends on management and other environmental factors such as wind speed and humidity of the air.

The generally accepted range of relative humidity for calf barns is between 60 and 80 % with an optimum around 65 % which is not too humid to dissipate excess heat and not too dry to dry out the respiratory pathways predisposing the mucous membranes to infectious and noxious agents present in the inhaled air. Air humidities of more than 80 % can lead to condensation on the walls and ceiling increasing the risk of wetting the animals by water dripping off these surfaces. High relative humidities can also impair the insulation properties of the walls increasing heat losses. Cold and humid air at high velocities can considerably increase the heat loss of animals. Lundborg et al. (2005) showed that draughts greater than 0.5 m/s measured close to the animal, significantly increased the odds ratio for moderate to severe respiratory sounds.

The higher the humidity the higher the risk of wet skin and cooling and shivering. High air humidity increases the probability that bacteria survive in an airborne state and are transmitted between animals in the same pen and between animal pens (Wathes, 1994). There are existing numerous reports from 1960s onwards of the survival of bacteria and viruses employing simple regression models to describe the loss of viability of microbes over time. However, these models lack an insight into biophysical and biochemical mechanisms of cell and virus death. As long as we do not understand these mechanisms, the measures to reduce the air pollutants are limited to either increased ventilation or increased air space. The smaller the air space per animal the more sophisticated the ventilation system must be. The influence of air space was demonstrated by Wathes (1994) showing that doubling of the air space in a calf barn from 6 to 12 m^3 per calf had the same effect on the concentration of airborne bacteria as a six fold increase in ventilation rate (air exchange rate). An air space of 6 to 8 m^3 per calf was recommended by Hilliger (1990) from experience.

9.6.2. Air Quality

Aerial pollutants in confined animal houses are widely recognised as detrimental for 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, such as enzootic bronchopneumonia.

The factors can be inadequate environmental conditions, e.g. too low temperatures, high ammonia concentrations and poor ventilation resulting in low air quality.

Poor air and surface hygiene in calf buildings are nearly always associated with intensive systems of husbandry, poor standards of management and high stocking densities (Wathes 1994). The most common aerial pollutants in calf housing are summarised in Table 9.1. Gases such as ammonia (NH_3), hydrogen sulphide (H_2S), carbon dioxide (CO_2), and more than hundred trace gases form an airborne mixture of bioaerosols composed of about 90 % organic compounds and can also contain endotoxin, antibiotic residues and further trace components. Significantly high amounts of endotoxins were found in calf house air while bacteria and dust are relatively low compared with pig and poultry houses and suggest that a high number of Gram-negative bacteria are present in the air. The average concentration of 64 ng/m^3 endotoxin given in Table 9.1 represents about 640 EU (endotoxin units) according to the new nomenclature. It seems rather high in comparison to a formerly proposed occupational threshold of 50 EU for humans at the work place (Rylander and Jacobs, 1997). It can be assumed that high endotoxin concentrations in calf house air may substantially contribute together with the other bioaerosol compounds and the physical environment to the high level of respiratory disorders in young calves up to 105 days (Assie et al., 2004). In general, there is little detailed knowledge on the specific composition of bioaerosols in calf keeping systems and which factors cause respiratory diseases. Assie et al. (2004) found e.g. a tendency to higher repiratory disorders in non-weaned calves reared in loose-housing yards compared with tied-cow stalls. The highest incidence rates of cases were observed between November and January, while daily meteorological conditions obviously did not influence incidence rates.

9.6.2.1. *Ammonia (NH_3) and hydrogen sulphide (H_2S)*

One of the most detrimental gases in calf barns is ammonia which is formed by bacterial degradation of nitrogen containing compounds in urine and faeces. It is the most widespread naturally occurring alkaline gas in the atmosphere and a strong irritant in animals and humans. Concentrations in the air of more than 20 ppm can impair the proper functioning of the mucous membranes of the respiratory tract and predispose to infection. In a recent study Lundborg et al. (2005) found that the risk for respiratory disease was significantly associated with an ammonia concentration below 6 ppm (OR: 0.42; $p<0.05$).

High concentrations of hydrogen suphide can be released in high amounts from stored liquid calf manure when it is stirred up before removal from the slurry pit of the barn. Concentrations of about 700 ppm are acute fatal.

9.6.2.2. *Air and surface hygiene*

The composition of the inhalable and respirable particles in animal houses is associated with compounds such as dried dung and urine, skin dander and undigested feed. The majority of bacteria found in shed airspace have been identified as gram-positive organisms, with staphylococci spp. predominating (Cargill et al., 1998). A survey by Heinrichs et al. (1994) showed the importance of good ventilation which removes dust and other respirable particles as well as noxious gases and is essential for calf health. Adequate ventilation is seen as vital to help to reduce the incidence of respiratory disease. Air inlets should be above calf height and the outlet at least 1.5 m above the inlet (Howard, 2003). However, heating and ventilation in combination with an air filtration system significantly improved the environment in a calf house but did not completely eliminate pneumonia (Bantle et al., 1994). This may have to do with other factors such as ambient temperature. In a recent study by Reinhold and Elmer (2002) some compromise in lung function (compared with controls) was seen in calves exposed to an ambient temperature of 5 ºC.

9.6.2.3. *Light*

In the past, veal calves were often kept in dark to reduce muscle activity but the requirements for light have increased over the last 20 years from 15 to 20 lux (Bogner and Grauvogel, 1984), to over 20 lux (IRPS, 1985) to 80 lux for at least 10 h and according to daylight circadian rhythm. (*Tierschutz-Nutztierhaltungsverordnung Germany, 2001*). There is wide agreement that calves need light for orientation in their boxes or pens and for social contact. A precise threshold has not been determined.

9.6.2.4. *Air movement*

There is a need for air movement around calves to supply fresh air and to remove excessive heat, moisture and air pollutants (gases, dust, microorganisms). Good ventilation systems provide this exchange. However, high air speeds close to the animals can lead to draughts and should be avoided. Draughts happen when part of an animal is hit by an air stream with a higher velocity than the ambient air movement and which has a substantially lower temperature than the surrounding air, causing a feeling of cold and physiological reaction in that particular part of the body. Draught can lead to poor welfare and disease when it continues and the animal cannot escape, e.g. when it is tethered. It is generally recommended that wind speeds around animals should be between 0.1 m/s in winter (least value) and about 0.6 m/s in summer. These values strongly depend on relative humidity and temperature of the air and whether the skin of the animals is dry or wet, full fleece or shorn. In confined buildings this complex relationship between the various factors is strongly influenced by the ventilation system and the ventilation rate which is necessary for the number of animals kept in the animal house. It seem useful to develop a more comprehensive model for the interaction of the different air quality compounds and the air exchange rate to improve our understanding of the welfare and health impacts arising from the air environment.

9.6.3. Ventilation

Ventilation plays an essential role in improving air quality in calf barns. This applies to free ventilated and forced ventilated houses. Calculations of ventilation rates are usually based on heat removal in summer and moisture removal in winter, and give some guideline temperatures and humidities of the air which should not be exceeded (e.g. CIGR, 1994; DIN 18910, 2004). Ventilation rates in calf barns can only be calculated satisfactorily for confined buildings. Minimum ventilation rates around 10 m^3 per 100 kg live weight should be sufficient to keep the air quality within acceptable limits if the air distribution system ensures an even air exchange in all parts of the building. Such guidelines (CIGR) and Norms (DIN 18910, 2004) cannot guarantee healthy calves but they can substantially help in designing confined calf houses. It seems useful to standardise the air quality and ventilation requirements for confined calf houses in Europe in order to reduce respiratory disorders, suffering of the animals and economic losses.

Table 9.1. Common air pollutants in calf houses

Gases	Ammonia, hydrogen sulphide, carbon monoxide, carbon dioxide, 136 trace gases, osmogens
Bacteria/Fungi	10,000 cfu/m^3 air 80 % Staphylococci/Streptocococi
Dust	e.g. 0.55 mg/m^3 inhalable dust
Endotoxin	e.g. 64 ng/m^3 in a calf barn

There are thresholds defined only for ammonia (20 ppm), hydrogen sulphide (5 ppm) and carbon dioxide (3000 ppm). For carbon monoxide (30 ppm) and inhalable dust (e.g. 4 mg/m^3 Germany) occupational health limits exist. For bacteria and endotoxin no thresholds designed yet.

9.7. Human-animal relationships

The 1995 report highlights two aspects of human-animal relationships:

- the skills and motivations of caretakers to raise healthy calves, which are of particular importance for indoor calves and in large groups and are linked to the health status of calves;
- the physical contacts between caretakers and calves to improve subsequent reactions of calves to humans.

It recommends careful monitoring (by the same person throughout rearing) and careful handling to habituate calves to human contacts.

Recent studies confirmed that the stockpersons have a great impact on both the productivity (e.g. growth) and the welfare of farm animals (stress responses, fear reactions during handling) (Boivin et al., 2003; reviewed by Hemsworth and Coleman, 1998). The effect of stockmanship is two-fold: good stockmanship leads to healthy animals and less stressful human-animal interactions.

Stockman skills are associated with positive attitudes towards work and towards animals. In calf production, a better health status is observed on farms where the caretaker (also the owner) believes that calves are sensitive animals and he/she has a positive attitude towards farming tasks in calf production (Lensink et al., 2001b)

Contacts given by stockpersons to animals depend also on human attitudes. Stockmen that are positive towards gentle contacts with calves (e.g. stroking, talking) are more likely to provide calves with such contacts (Lensink et al., 2000a).

It is not only the duration of contact but also its nature that plays a role. Gentle contacts (e.g. stroking, talking, letting a calf suck fingers, offering food) lead to calves approaching humans as they have less fear of handling (Boivin et al., 1998; Jago et al., 1999; Lensink et al., 2000b). Whereas rough contacts (e.g. hitting with a stick, use of nose tongs or an electric prod) lead to fear reactions in presence of humans (Rushen et al., 1999). The electric prod seems particularly stressful to calves (Croney et al., 2000) and noises (metal clanging, shouts by humans) will also increase stress during handling (Waynert et al., 1999).

During transport to slaughter, less fear responses to handling (e.g. due to regular previous experience of gentle contact) not only improves the welfare of calves but also improves meat quality (lower pH and lighter colour) (Lensink et al., 2000c; Lensink et al., 2001a).

Cattle are able to distinguish between familiar and unfamiliar persons (Rybarczyk et al., 2003; Taylor and Davis, 1998). Among familiar persons, they distinguish between those who have been rough with them and those who have been gentle (e.g. stroking, brushing, and offering food) (De Passillé et al., 1996).

Compared with individually housed calves, calves housed in groups tend not to approach humans and are more difficult to handle (Lensink et al., 2001b). The presence of the dam can lower the effectiveness of gentle contacts with animals (Boivin et al., 2002). Contact early after birth can be more effective that contact provided later; however, regular contact is necessary to maintain a lower level of fear responses to humans (Boivin et al., 2003).

9.8. Dehorning and castration

The 1995 report recommended:

- to dehorn calves between 1 – 3 weeks by cauterisation with adequate anaesthesia and analgesia (no details given)
- to castrate calves at 3 months with adequate anaesthesia and analgesia (no details given)

9.8.1. Dehorning

Dehorning means the removal of horns while disbudding (on young animals) corresponds to the removal of horn buds. Disbudding can be performed by cautery, or by rubbing or covering the horn buds with a chemical (NaOH, KOH or colloidon), or by amputation with a specifically designed sharp tool, a scoop.

Recent publications confirmed that disbudding and dehorning are painful to cattle (Stafford and Mellor, 2005).

The existence of pain is deduced from observations of an increase in blood cortisol for several hours after dehorning and from specific pain related behaviour: head shaking, ear flicking (Faulkner and Weary, 2000)

Disbudding without anaesthesia or analgesia is painful to calves, even when young, and dehorning with a wire-saw is painful to cows even if anaesthesia is carried out (Taschke and Folsch, 1997).

Disbudding by cautery (hot iron, electric tool) and chemical disbudding (NaOH) are less painful than disbudding with a scoop (Stilwell G. et al., 2004a; Stilwell G. et al., 2004b; Sylvester et al., 1998).

Local anesthesia (5-6 mL lidocaine or lignocaine 2% around the corneal nerve 15-20 min before disbudding) can abolish the pain that immediately follows cautery and largely diminishes the pain caused by disbudding by other methods; the effects last for the few hours and when the nerve block has lost its effect, pain ensues (Mellor et al., 2002; Stilwell et al., 2004b; Sutherland et al., 2002b).

Local anesthesia plus analgesia with a non-steroidal anti-inflammatory drug (NSAID)(e.g. 5 mL Flumixin meglubine or 3 – 3.75 mg/kg ketoprofen (10%) 15 min before disbudding) abolish pain caused by cautery but only reduces it in the case of disbudding with a scoop (unless it is followed by cautery) (Sylvester et al., 1998; Faulkner and Weary, 2000; Sutherland et al., 2002a; Stilwell et al., 2004b).

In their review, Stafford and Mellor (2005) concluded that cautery is the less painful method for disbudding and that optimal pain relief is obtained with Xylazine sedation, local anaesthesia and analgesia with a non- steroidal anti-inflammatory drug.

9.8.2. Castration

The 1995 report recommend that when cattle are to be castrated this should be done at around 3 months of age and under appropriate anaesthesia and analgesia.

Methods to castrate cattle are: clamping (generally with a Burdizzo clamp), constriction of the blood supply with a rubber ring, and surgical removal (cutting of the scrotum then traction on the testes and spermatic cords or cutting across the spermatic cross). Calves are castrated as early as 1 week up to over 6 months (see review of practices used in UK by Kent et al., 1996).

Recent studies confirm or showed that:

Castration is painful whatever the method used and whatever the age of the calf (Molony et al., 1995; Robertson et al., 1994). Acute pain is deduced from the observation of increases in blood cortisol and abnormal postures (immobility), and behaviours such as foot stamping and kicking. Chronic pain is deduced from the observation of activities targeting at the site of castration (e.g. licking, head turning, alternate lifting of the hind legs, and slow movements of the tail) as well as abnormal standing.

Burdizzo clamping and surgery induce acute pain for at least 3 h (Molony et al., 1995; Obritzhauser et al., 1998; Robertson et al., 1994). Burdizzo is less painful than surgery (Stafford et al., 2002) but may also cause pain for longer (at least 48 h) due to scrotal inflammation (Stilwell, pers. comm.).

Castration with a rubber ring causes both acute and chronic pain for at least 1.5 mo (Molony et al., 1995)

Castration is less painful for 1 wk old calves than for 3-6 wk old calves (Robertson et al., 1994) and it is less painful at 1.5 months than at older ages (Ting et al., 2005).

Local anesthesia (3 mL Lignocaine 2% into each testicle through the distal pole) abolishes the acute pain associated with castration by a ring or a band (Stafford K.J. et al., 2002). It reduces but does not abolish acute pain associated with castration by surgery or clamping (Fisher et al., 1996; Stafford et al., 2002).

Analgesia with a NSAID drug (e.g. Ketoprofen 10% 3mg/kg body weight) reduces the pain associated with clamping (Ting et al., 2003). Some analgesics (e.g. Caprofen, 1,4 mg/kg body weight) are effective for longer than 24h and are thus more likely to provide more effective pain relief (Stilwell, comm. pers.). Local anaesthesia plus analgesia appears to eliminate the acute pain due to castration by surgery or clamping (Stafford et al., 2002).

10. Calf diseases and use of antibiotics

The most important diseases in young calves are diarrhoea and respiratory disease (Olsson et al., 1993; Sivula et al., 1996; Virtala et al., 1996a, Donovan et al., 1998; Lundborg, 2004). A prospective study was carried out on 94 randomly selected beef herds in the Midi-Pyrenees region in France (Bendali et al., 1999). The objective was to describe diarrhoea and mortality in beef calves from birth to 30 days of age. Calves (3,080) were followed from December 1995 to April 1996, and a total of 700 visits allowed records of herd management practices, individual data and environmental conditions to be collected. The incidence rate for diarrhoea during the neonatal period was 14.6%, and varied markedly between herds. Eighteen herds did not suffer from diarrhoea, while five herds had an incidence of more than 50%. Results indicate that 52% of diarrhoea appears during the first week and only 15% after the second week of life. The greatest risk of diarrhoea for a calf was during the first and second weeks of life (7.9 and 6.5 times, respectively). The month of birth was also significantly associated with morbility, the highest incidence was observed in December and March (17.6% and 23.6%, respectively). The global mortality rate was 3.6% and was two-times higher in December than in other months. Forty per cent of herds did not exhibit mortality, and 10% had mortality rates greater than 10%. In a study of calf health in 100 cow-calf herds in Switzerland, Busato et al. (1997) found that of 1270 calves included in the study 22% of the calves had been treated by a veterinarian. Of those, 36% of the treatments were given because of diarrhoea and 27% because of respiratory disease. Another Swiss study (Frei et al., 1997) showed that in 113 Swiss dairy herds, the incidence density (ID) per 100 animal-years of diarrhoea, omphalitis (infection of the navel), respiratory diseases and other diseases were 35.0, 13.9, 13.5 and 7.2 respectively. In a study of nine herds and 892 calves with Swedish Red and Whites, Swedish Holsteins and some crossbreeds the effect of group size on health was studied (Svensson and Liberg, 2006). After transfer to group pens (at 21-53 days of age) 19.0% of the calves had diarrhoea, 9.8% had omphalophlebitis/umbilical abscess, 31.3% had a clinical respiratory-tract disease and 1.4% had weak calf syndrome. Of all calves, in 7.3% there was associated general condition impairment. In 37.4% of the diarrhoea cases antibiotics were used as treatment and of the clinical respiratory-tract cases 54% were treated with antibiotics.

Several factors have been associated with an increased risk of infectious disease during the first 90 days of life, particularly factors affecting serum immunoglobulin concentration. In a study of 122 dairy herds in south-west Sweden, Svensson et al. (2003) clinically monitored the health of 3081 heifer calves from birth until 90 days of age. 23% of the calves developed one or more diseases during this period. Most of the 317 diarrhoea cases were mild (68%) whereas of the 221 cases of respiratory disease 43% were severe. The total morbidity was 0.081 cases per calf-month at risk and the incidence rates of arthritis, diarrhoea, omphalophlebitis, respiratory disease and ringworm were 0.002, 0.035, 0.005, 0.025 and 0.009 cases per calf-month at risk respectively. Odds ratios were calculated for severe diarrhoea in calves born in the summer (OR: 1.7) and receiving colostrums through suckling instead of a bucket or nipple (OR: 1.8). It has been shown that calves left with their mothers have a delayed/longer time to ingest colostrum and often fail to ingest adequate volumes (Rajala and Castrén, 1995). Svensson and Liberg (2006) found that the health status of the mother cow 280-50 days before calving, length of dry period, retained placenta and somatic cell count were predisposing risk factors for respiratory disease in the calf. Svensson et al. (2003) were also able to demonstrate that the odds ratios for respiratory disease and increased respiratory sounds were increased in calves housed in large group pens with an automatic milk-feeding system (OR: 2.2 and 2.8). Similar results have been reported by Maatje et al. (1993) and Plath (1999). There was a decreased odds ratio for respiratory disease if calving was supervised (OR: 0.7) (Svensson et al., 2003). If birth was taking place in individual maternity pens or in tie stalls instead of in cubicle or group maternity pen, the odds ratio for increased respiratory sounds was 0.5 or 0.6 respectively. 30% of the diarrhoea cases were treated with antibiotics whereas 47% of the respiratory cases were treated using antibiotics. In another study of nine farms, Svensson and Liberg (2006) found that in pens for six to nine calves there was a significantly reduced risk of clinical respiratory tract disease (OR: 0.69-0.72) compared with pens with 12-18 calves and there was also an association with the age at transfer to the group pen. The risk of diarrhoea was not affected by housing the calves in differently sized groups. However, calves housed in large sized groups grew significantly less quickly (approximately 40 g/day) than calves housed in groups of six to nine.

Serological responses to respiratory viruses (e.g. bovine respiratory syncytical virus, parainfluenza virus, corona virus and viral diarrhoea virus) showing that animals within a herd are usually either all seropositive or all seronegative, indicate that infections spread to all calves in the herd when introduced or activated (Hägglund et al., in press) and hence that aerosol is an important means for the spread of viruses. However, an infected animal is not equivalent to a diseased animal. It has been shown that calves housed in adjacent pens can maintain quite different levels of disease. Svensson and Liberg (2006) reported that calves in a group of 16 had a significantly higher incidence of clinical respiratory disease that calves in an adjacent pen kept in groups of 8. Engelbrecht (2005) reported calves transferred to group pens in a batchwise manner had significantly higher prevalence of diarrhoea and respiratory disease than calves in adjacent pens that were transferred to and from the group pen continuously. In both studies calves had no direct contact with calves in adjacent pens. These results indicate an important 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. Svensson and Liberg (2006) also reported that the age at transfer from single pens to group pens was associated with the risk of respiratory disease, indicating that delaying transfer to after two weeks of age might be preferable for health reasons.

10.1. Enteritis

Enteritis is the most common disease in calves less than a month old (Virtala et al., 1996b; Wells et al., 1996; Radositis et al., 1999). Diarrhoea is caused by dietary factors or caused by infections due to viruses, bacteria or parasites. Routines in distributing colostrum to the calf are crucial for transferring immunoglobins to the calf and to obtain a good health. (Rajala and Castrén, 1995; Liberg and Carlsson, 1998). Enteritis is clinically recognized by the observation of faeces with a looser consistency than normal. Colour as well as smell of the faeces might be affected. Diseased animals exhibit fever and may be inactive usually as a result of dehydration and possibly acidosis (Radositis et al., 1999). Usually it is not possible to differentiate between different agents causing the diarrhoea by clinical findings.

Rotavirus is worldwide a major cause of diarrhoea and it is an often detected agent among young calves with enteritis (E.g. Björkman et al., 2003). Rotavirus affects calves usually between 1 and 8 weeks of age and the diarrhoea can vary from very mild to lethal (de Leeuw et al., 1980). The virus is excreted through faeces of infected animals and is very resistant for several months, that is why cleaning of pens is necessary to break the infectious path (Saif and Theil, 1990).

Bovine coronavirus is most commonly seen in calves at about 1 week of age (Fenner et al., 1987).

Escherichia coli K99+ may cause diarrhoea in young calves although it is a part of the normal intestinal flora. Poor routines for transferring colostrum to the calf, stress etc. might trigger a diarrhoea outbreak (Wray and Thomlinson, 1975). Severity of the disease may vary but with a high proportion of mortality (Radositis et al., 1999). Only amoxicillin is recommended for the treatment of diarrhoea caused by E. coli bacteria associated by systemic illness. In calves with diarrhoea and no systemic illness (normal appetite for milk, no fever), the health of the calves should be monitored carefully and no antibiotics should be administered (Constable, 2004).

Bovine Viral Diarrhoea may occur at any age. The infection causes an immunosuppression in infected animals which may lead to infections with other intestinal or respiratory pathogens (Elvander et al., 1998; de Verdier Klingenberg, 2000) and it may increase the mortality rate in the herd (Ersböll et al., 2001).

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. Calves are infected orally and clinical signs are fever and bloody diarrhoea (Carter and Chengappa, 1991).

Clostridial infections in the gastrointestinal tract are sometimes a problem in calves. Usually, the calf, less than 10 days of age, develops haemorrhagic, necrotic enteritis and enterotoxemia, often associated with clinical abdominal pain. Affected calves exhibit tympany, hemorrhagic abomasitis and ulcerations in abomasum (Songer and Miskimins, 2005). As yet, relatively little is known about the etiology aside of the participation of *C. perfringens* type A. Overfeeding or feeding which decreases gut motility is suggested to contribute to the occurrence of the disease (Songer and Miskimins, 2005)

Eimeria spp. are frequently present in cattle in Europe (Bürger, 1983). Predominantly *E. ellipsoidalis* was found in housed calves in East Germany (Hiepe et al., 1978) and the distribution may differ from country to country. Svensson (1993) found a predominance of *E. alabamensis* in Swedish dairy calves. Clinically, signs are rarely seen but diarrhoea can occur usually as a result of exposure at the first grazing season in areas contaminated with oocysts (Svensson, 1993). There is evidence that infection rates have increased since the prohibition of tethering (Berthold, pers. com.).

Emeria bovis and *Emeria zuernii* are other intracellular protozoan parasites belonging to the same group and with a worldwide distribution (Urquhart et al., 1991). It is often seen in calves between 1-6 months of age (Holliman, 2000). The disease is triggered by stress such as very cold or hot climate (Urquhart et al., 1991).

Cryptosporidial infection in calves less than 30 days old is significantly associated with the risk of infection in the dairy herd. The risk increases when animals are grouped together and when hygiene and management practices are deficient (Attwill et al., 1999; Mohammed et al., 1999). Factors associated with a decreased risk of infection in preweaning calves were shown to be use of ventilation in calf rearing areas, daily addition of bedding, feeding of milk replacer, daily disposal and cleaning of bedding and use of antibiotics. In addition, postweaning moving of animals was also associated with a decreased risk of infection with *C. parvum* (Mohammed et al., 1999). Perryman et al. (1999) showed that with appropriate supply of immune colostrum, diarrhoea can be prevented. Two species are distinguished: *C. parvum* and *C. andersoni*, although only *C. parvum* has been shown to be associated with diarrhoea (Lindsay et al., 2000).

Cryptosporidia parvum is an intracellular protozoan parasite belonging to Coccidiae. In the UK *C. parvum* has been considered to be one of the most common agents in neonatal diarrhoea in calves (Reynolds et al., 1986). In Denmark it was found mixed with other enteropathogens in 45% of diseased calves (Krogh and Henriksen, 1985). In two recent Swedish studies it was found in 19% and 11% respectively of calves with diarrhoea (De Verdier Klingenberg and Svensson, 1998; Björkman et al., 2003).

10.2. Respiratory disease

The most common form of respiratory disease affecting young calves is enzootic pneumonia (Ames, 1997; Radositis et al., 1999). It is considered to be a multifactorial disease with causative agents, individuals and environmental factors as important components (Ames, 1997).

Enzootic pneumonia usually affects calves between 1 and 6 months of age (Radositis et al., 1999). The signs usually found are fever, nasal discharge, coughing and increased respiratory sounds when lung auscultation is performed. Secondary bacterial infections may occur which might increase the fever. Diagnosis of etiological factors may be achieved from serological examinations, viral examinations from nasal discharge or at autopsy.

Bovine respiratory syncytical virus (BRSV) is a worldwide present agent (Baker, et al., 1997) with seasonal peaks during autumn and winter (Baker and Frey, 1985). The virus is thought to be transmitted from infected animals, by transmission of humans or by airborne transmission (van der Pohl et al., 1993; Elvander, 1996). Morbidity can be high but mortality is usually low (Baker et al., 1997). Another virus with a milder course of disease is Para-influenza-3 virus but the virus can cause immunosuppression predisposing to secondary bacterial infections (Adair et al., 1999).

The most common bacterial pathogens in calves with respiratory disease are Pasteurella multocida and *Manheimia hemolytica* (Mosier, 1997; Bengtsson and Viring, 2000). These agents are usually found in the bovine nasopharynx and may, as a result of viral disease proliferate and colonise the lungs of the calf (Kiorpes et al., 1988).

Haemophilus somnus was shown to be commonly present in Danish calves (Tegtmeier et al., 1996) where no such agents were found in Swedish calves (Bengtsson and Viring, 2000). *Arcanobacterium pyogenes* and *Staphylococcus aureus* (Carter and Chengappa, 1991) as well as Mycoplasma spp. (Ames, 1997) are other agents found in immune depressed calves with other infections.

10.3. Other infections

Infections may occur in the umbilical cord (Radositis et al., 1999) of newborn calves. Various bacteria are found and through a bacteraemia infection may spread to to joints, meninges and internal organs (Radositis et al., 1999). Omphalitis is painful in response to palpation of the umbilicus.

Arthritis is often secondary to an umbilical infection and usually affects the calf during its first month resulting in warm and swollen joints, fever and lameness (Radositis et al., 1999).

The effect of environmental factors on the risk of diarrhoea and respiratory disease was studied by Lundborg et al. (2005) in the same 122 farms and 3081 calves as previously reported by Svensson et al. (2003). They found that the placing of calf pens along an outer wall was associated with a significantly higher risk of diarrhoea (OR: 1.92). An ammonia level below 6 ppm was significantly associated with the risk of respiratory disease (OR: 0.42) but variations of ammonia levels were low, while the odds ratio for increased respiratory sounds was associated with a BVDV infection in the herd (OR: 2.39) and draught (OR: 3.7). Absence of draught was associated with the risk for infectious diseases other than diarrhoea and respiratory disease (OR: 0.42), a finding which could not be explained by the authors. An increased calf mortality rate in herds with a BVDV infection has also been reported by Ersböll et al. (2001) and the eradication of BVDV infection in a dairy herd has been demonstrated to decrease the incidence of calf diarrhoea (De Verdier Klingenberg et al., 1999).

Typically, clinical experience is 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 where they were born to a specific rearing farm than if they are reared on the farm they were born on.

Calves reared indoors commonly develop complex respiratory diseases. Bergmann (1987) reported that 62% of calves of a large fattening unit with several thousand calves suffered from bronchopneumonia within the first six month of their life. Similar figures were reported from Herrmann (1987) with a prevalence of 50 to 61%, Lämke et al. (1989) 45% and Busato et al. (1997) 52%. The disease seems to be continuously present and does not come or go in form of isolated outbreaks. Therefore Kielstein et al. (1975) called it enzootic pneumonia. It is a typical multifactorial disease caused by a variety of different types of micro-organisms which are always present but becoming a nuisance only when additional factors contribute (Grunert, 1993).

10.4. Importance of respiratory and digestive diseases in calves

The most prominent reasons for losses of calves in the first weeks of life are respiratory and digestive disorders (Katikaridis 2000; Girnus, 2004). Losses can reach 6 to 12 per cent in the first six months of rearing (Berchtold et al. 1990 and others). Estimations show that the financial losses are reaching 100 million €/year in Germany (Biewer, 2001). This sum does not cover the costs of veterinary treatment and reduced growth rates of the calves. There are several epidemiological studies on the different diseases in calves in the first couple of weeks of life (Katikaridis, 2000; Biewer, 2001; Girnus 2004, Svenson et al., 2006). Heinrichs (1991) reported that 64% to 70% of 2,273 fallen calves coming for post-mortem dissection showed digestive disorders. Calves 4 weeks of age died predominantly of respiratory diseases (40% to 70%). An investigation of 3,334 calves less than 4 months shows that enzootic bronchopneumonia can already start with the age of 2 weeks (Buhr, 1996). The calves were not older than 4 months. 49 % displayed abomasum enteritis. 32% of the animals suffered from pneumo-abomasal enteritis. Only 4.5% of the fallen animals suffered from a distinct pneumonia. An epidemiological survey of calf losses in free range and suckling cow herds showed that the percentage of calf losses is increased with herd size. 97% of herds with less than 20 suckling cows had a calf mortality of less than 10%. In herds with more than 300 cows, these were 9% of all investigated farms, calf losses were higher than 10% (Laiblin and Metzner, 1996). Main disorders were again diseases of the digestive tract (50 %) and respiratory tract (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.

The epidemiological data from the vast majority of investigations suggest considerable differences in morbidity and mortality of calves among different farms. This implies that the management and housing conditions greatly influence heath, welfare and survival of calves in the first 6 months of their life. The situation was not substantially improved by vaccination of cows against a cocktail of infectious agents causing diarrhoea.

There are no experimental studies available to indicate whether or not there is any advantage to calf welfare of preventing individuals in separate pens from social contact as opposed to a disadvantage to calf welfare of greater spread of disease with housing where such social contact is possible. In general, disease spread occurs in buildings with continous air space and contact is not a clearly identified factor. However, recent results indicate an important 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 (see chapter 8/9/10).

10.5. Antibiotic resistance

Although the use of antibiotics as growth promoters is being progressively restricted through EU regulations, 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. In a study of antibiotic resistance, Berge et al. (2003) found high levels of multiple resistance in calf commensal faecal *Escherichia coli* both on farms with calf production and on dairy farms. The investigators found that *Escherichia coli* from calves on dedicated calf-rearing facilities was more likely to be multiple-resistant than *E. coli* from dairy-reared calves (OR: 2.4) (Berge et al., 2005a). In her PhD thesis, Berge (2004) showed that both prophylactic use of antibiotics in milk replacer and individual antibiotic therapy increased the resistance of faecal *E. coli* in calves. *E. coli* isolates from calf ranches were the most resistant, with in order of decreasing levels, isolates from feedlots, dairies and beef cow-calf farms. On organic dairies fewer resistant *E. coli* isolates were found in comparison with conventional dairies. *E. coli* isolates from beef cow-calf farms were less resistant if the farms were on remote locations compared to those on locations close with dairy intense areas.

The use of antibiotics to treat clinical illness will increase the welfare of the animal given that the drug has a beneficial clinical effect. 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 in a longer perspective as well as to man (Aarestrup and Wegener, 1999).

In a clinical trial on a calf ranch in California, it was shown that the most important factor for decreasing morbidity and mortality was to ensure adequate passive transfer through colostrum (Berge et al., 2005c). Thereafter, the ability to use antibiotics for clinical treatment of disease was important to decrease morbidity and mortality. The use of antibiotics in the milk replacer had a minor protective effect on calf health. The authors concluded that in order to minimize prophylactic use of antibiotics, adequate passive transfer of colostrum needs to be assured. Furthermore measures need to be taken to optimize nutrition, decrease environmental stress and pathogen load on the farms.

In the same study, the antibiotic resistance patterns of the commensal faecal *E. coli* of calves receiving antibiotics in the milk-replacer, antibiotics for clinical disease, and no antibiotic therapy were compared (Berge et al., 2004). The study showed the emergence of highly multiple resistant *E. coli* in the calves receiving antibiotics in the milk-replacer. The commensal faecal *E. coli* were predominantly resistant to at least 10 of 12 antibiotics tested. The resistance covered the antibiotics available for clinical therapy. Antibiotic treatments for clinical disease resulted in a transitory shift to more resistant faecal *E. coli*, but the effect was not detectable approximately 7 days post-treatment.

The effect of clinical therapy with antibiotics was similarly assessed in steers in South Dakota. In a feedlot study a single dose injectable florfenicol to steers resulted in transitory shifts to increasing levels of multiple resistant *E. coli* in the faeces. The *E. coli* from the treated steers were not only more resistant to chloramphenicol (same antibiotic group as florfenicol), but were increasingly resistant to several other antibiotics in other antibiotic classes. (Berge et al., 2005b)

In dairy cattle it has been estimated (Kelton et al., 1998) that between 2 and 55% of all lactations include a mastitis infection. Most of these cases are treated with antibiotics. Milk must be withheld from sale during the treatment and for the compulsory withdrawal period. Such “waste milk” is often fed to calves as it is the most economical alternative from the farmer’s perspective. Earlier studies have previously given various results on how antibiotic resistance develops as a result of the use of this procedure. Recently, a controlled, multiple-dose experiment by Langford et al. (2003) found an increasing resistance of gut bacteria to antibiotics with increasing concentrations of penicillin in milk fed to dairy calves.

In a multi-farm study in California (Berge et al., 2006) including 26 dairies, no association was found between increasing levels of antibiotic resistance in calf faecal *E. coli* and the consumption of waste milk. It should, however, be noted that mastitis in these dairies are predominantly treated with intra-mammary antibiotics (cephalosporins) and injectable antibiotics are rarely used for mastitis treatments (Berge, non-published data).

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. Further, there is a risk that the use of "waste milk" for calves will increase antibiotic resistance in gut bacteria in calves.

11. Food safety aspects of calf farming

11.1. Introduction

Foodborne hazards that can be present on calf farms include biological and chemical hazards. Biological hazards associated with calf farming include following main examples: a) bacterial foodborne pathogens *Salmonella* spp., human pathogenic VTEC (HP-VTEC), thermophilic *Campylobacter* spp., and *Mycobacterium bovis*; and b) parasitic foodborne pathogens *Tania saginata cysticercus* and *Cryptosporidium/Giardia.* On-farm control of chemical foodborne hazards is outside the scope of this Chapter and will not be considered.

Faecal shedding of foodborne pathogens can occur in calves and adult bovines without symptoms of disease; but the shedding pattern may differ between the two age categories. In the conventionally reared animal the intestinal tract becomes colonised from birth by combinations of bacterial species until the characteristic and complex flora in the adult animal is achieved. In the early stages of the process infections with bacterial pathogens are common. Once the indigenous flora is established it resists colonization by pathogens and other 'foreign' strains by competitive exclusion (Linton and Hinton, 1987). The gut flora of the bovine species changes with ruminal development and the population of faecal coliforms of the adult differ markedly, both qualitatively and quantitatively, from that of the young; particularly that of veal calves fed milk replacer (Smith, 1961). Faecal shedding of pathogens by food animals including calves plays a major role in their transmission to humans; which can occur through various routes including contaminated food, water, or direct contact.

11.2. The occurrence of Salmonella spp. on calf farms

The genus *Salmonella* contains two species (*Salmonella enterica* and *S. bongori*) based on phenotypic criteria; the species *S. enterica* is divided into 6 subspecies (*enterica*, *salamae*, *arizonae*, *diarizonae*, *houtanae* and *indica*) whilst the serology, based on the characterisation of the somatic (O), flagellar (H), and envelope (Vi) antigens, allows classification into over 2,400 serotypes (Opinion on *Salmonella* in Foodstuffs; SCVPH 2003b). Beef including veal has been implicated in foodborne salmonelosis.

Some early studies (Gronstol et al., 1974a; Gronstol et al., 1974b), based on experimental *Salmonella* infection of calves, described virulence, spread of infection and the effects of stress on the carrier status. Hinton et al. (1983, 1984a, 1984b) determined the incidence of *Salmonella* Typhimurium (DT 193 and DT 204) excretion by veal calves fed milk replacer and report that, while initially low on in-take at around 6 days of age, its incidence rose to a peak by 14 days. The level of salmonella contamination of the environment also affects the incidence of infection in housed animals (Hinton et al., 1985a, 1985b).

Provided calves are reared in separate fattening units and slaughtered on separate slaughterlines the incidence of salmonellae in calves can be maintained at a very low level (Guinée et al., 1964). During meat inspection clinical salmonellosis is sometimes diagnosed in a herd of veal calves; however, the prevalences are usually of the order of magnitude of per thousand and the strains isolated are generally restricted to *Salmonella* Typhimurium (occasionally) and more commonly, *Salmonella* Dublin (up to 90%).

Although salmonellae may not be isolated from faeces, significant proportions of calves slaughtered commercially (4.3-14.3 %) have contamination involving hepatic lymph nodes, liver, mesenteric lymph nodes and, because of cross contamination, they may ultimately also be isolated from the carcass surface (Nazer and Osborne, 1976; Wray and Sojka, 1977). Studies conducted in The Netherlands in the late 1970's indicate that microorganisms may be released from lymph nodes through transport stress and may appear in the faeces. This results in young veal calves being cross-infected in transit and at markets; however, in Dutch studies faecal samples from no more than 3.5% of the animals were found to contain salmonellae on arrival at the fattening units (Van Klink and Smulders, 1990). Moreover, within 3 weeks of arrival, faeces samples become negative again (Van Zijderveld et al., 1982). Subsequent studies by the same workers (Van Zijderveld et al., unpublished, cited by Van Klink and Smulders, 1990) indicate that faecal samples from calves which had survived clinical salmonellosis also become culture-negative, albeit only after 6 weeks. These findings suggest that, provided stressful transport conditions are avoided and sufficient hygienic care is taken to avoid cross infection during transport to the abattoir, the extent of introduction of salmonellae to the veal slaughterline is indeed extremely low. This is substantiated by repeated failure to isolate salmonellae from carcass surfaces of veal calf populations, and from their livers and offal meats (Van Klink and Smulders, 1990).

As with other bacterial foodborne pathogens, antimicrobial resistance in *Salmonella* shed by calves represents an additional food safety risk. Numerous studies have shown that use of antimicrobials in food producing animals selects for resistance in non-typhoid *Salmonella* spp. and that such variants have been spread to humans (WHO, 2004; Walker et al., 2000; Fey et al., 2000). In general, antimicrobial resistance in *S.* Typhimurium isolates from bovines in the EU was widespread in 2004, with highest prevalence of resistance to ampicilin, sulfonamide, tetracycline and streptomycin (EFSA Zoonosis Report, 2005b), but the data does not relate specifically to calves.

11.3. Human pathogenic-Verotoxigenic Escherichia coli (HP-VTEC) on calf farms

VTEC is a group of *E. coli* that produces one or more verocytotoxins (VT) also known as Shiga toxins (STX), but not all members of this group cause foodborne disease in humans. In the Opinion on Verotoxigenic *E. Coli* (VTEC) in Foodstuffs (SCVPH, 2003c), VTEC that have been associated with causing human disease were referred to as human pathogenic VTEC (HP-VTEC).

Foods of bovine origin (e.g. beef, milk) have been implicated in a number of foodborne outbreaks caused by HP-VTEC (Borczyck et al., 1987; Chapman et al., 1993; Martin et al., 1986; Pennington, 1998; SCVPH, 2003a); these include several serotypes (e.g. O157, O26, O103, O111 and O145). When adult cattle were inoculated with VTEC O157, they showed no outward signs of infection and the organism was cleared from the gastrointestinal tract within two weeks (Wray et al., 2000). The organism seems to be a constituent of their naturally-occurring microflora, and longitudinal studies show most cattle occasionally carry *E. coli* O157 in their faeces (Hancock et al., 1997; Lahti, 2003). However, the prevalence of infection with HP-VTEC of, and the shedding patterns in, cattle can vary due to variable factors including age, immunocompetence status, husbandry conditions, season and geographical areas.

Prevalence of VTEC O157 is usually higher in younger animals (Synge, 2000; Cray and Moon, 1995; Hancock et al., 1997; Mechie et al., 1997; Van Donkersgoed et al., 1999). In calves, the prevalence of *E. coli* O157:H7 can range from zero to 20.0% prior to weaning, and often increases after weaning (Bonardi et al., 1999; Laegried et al., 1999). Calves normally show no, or little, sign of infection, perhaps only some excess faecal mucus (Myers et al., 1984; Synge and Hopkins, 1992; Brown et al., 1997; Richards et al., 1998; Wray et al., 2000); the shedding rate can fall rapidly in the first two weeks after inoculation and continue intermittently for several weeks. In the first three months of life on contaminated farms, faecal prevalence can increase from around 35% to 53%, possibly due to the decline in maternal immunity (Busato et al., 1999). Fasting showed little effect on the carriage and excretion of *E. coli* O157 in calves (Harmon et al., 1999). Less information is available on non-O157 HP-VTEC in calves that have potential to cause enterohaemorrhagic disease in humans, so establishing indicators for virulence and clarifying the epidemiology of such serotypes is needed.

11.4. Thermophilic Campylobacter spp.

According to the BIOHAZARD Scientific Report on *Campylobacter* in Animals and Foodstuffs (EFSA, 2005a), the most important species of C*ampylobacter* are the thermophilic species *C. jejuni* ssp. *jejuni, C. coli* and *C. lari*; other species which are known to cause human illness are *C. upsaliensis, C. fetus* ssp. *fetus* and *C. jejuni* ssp. *doylii*. The most common species recovered in human disease is *C. jejuni*.

Campylobacter spp. can be found throughout the intestine of cattle, but the level of the organism in the rumen is significantly lower than that found in the small intestine and in faeces (Stanley et al., 1998). The class of cattle also has an effect on the level of *Campylobacter* spp. found in the faeces; faeces may contain around 10^4 CFU/g in calves, around 10^2 CFU/g in beef cattle and around 70 CFU/g in adult dairy cattle. *Campylobacter* spp. are more often found in the faeces and intestine than in the rumen, while *Campylobacter jejuni* prevalence is much less than that of *Campylobacter hyointestinalis* (Ataby and Corry, 1998; Grau, 1988).

Campylobacter jejuni has been found in calves in 97% of beef farms, *Campylobacter coli* in 19% and *Campylobacter hyointestinalis* in 82% (Busato et al., 1999). Within the herds, zero to over 50% of the calves may be excreting *Campylobacter* spp.; 38% of the calves may be positive for *Campylobacter* spp. in herds without evidence of diarrhoeal disease (Myers et al., 1984). In this study, 72% of the isolates were *C. jejuni*. In a study of veal calves at slaughter, *C. jejuni* was found in 74% of calf rumen samples (in low numbers; <100/g) and in 54% of calf faecal samples (Grau, 1988), whilst *C. hyointestinalis* was found in 83% of calf rumen samples (in numbers $>10^5$/g) and in 71% of faecal samples. The coats of the calves were also contaminated, as 58% were positive for *C. jejuni* and 71% for *C. hyointestinalis.*

As with other bacterial foodborne pathogens, antimicrobial resistance in thermophilic *Campylobacter* spp. shed by calves represents an additional food safety risk. In 2004, although the total number of isolates was relatively small and the data are not related specifically to calves, some EU member states reported relatively high prevalence of resistance to quinolones, fluoroquinolones and tetracyclines in *Campylobacter* spp. including *C. jejuni* from bovines (EFSA Zoonosis Report, 2006) which can be an emerging public health concern.

11.5. Mycobacterium bovis

Generally, in 2004, the occurrence of bovine tuberculosis in the MS not having officially tuberculosis-free status decreased or showed insignificant increase (EFSA Zoonosis Report, 2005b), but the data does not relate specifically to calves. Other information on tuberculosis in calves have been analysed in, and is available from, some previous scientific opinions (EFSA 2003, Opinion on Tuberculosis in Bovine Animals; EFSA 2006, Opinion on visual inspection in veal calves raised in tuberculosis-free member states; SCVPH 2003a, Opinion on Revision of Meat Inspection in Veal Calves). Overall, information whether/how tuberculosis patterns differ between different calf farming system is insufficient. For the above reasons, and also because on-farm controls of tuberculosis are managed on the basis of herd health plans, they will not be further considered here.

11.6. Foodborne parasites

Information on *Taenia saginata cysticercus* in calves, the role of various related on-farm risk factors in the infection of calves, and an example of generic framework for risk-profiling of calf farms is available from previous scientific opinions (SCVPH 2003a, Opinion on Revision of Meat Inspection in Veal Calves; EFSA 2004a, Opinion on the risk assessment of a revised inspection of slaughter animals in areas with low prevalence of Cysticercus); therefore, the parasite will not be further considered here.

Cryptosporidium parvum and *Giardia duodenalis* are protozoan parasites that have caused disease in humans primarily via contaminated water or foods (e.g. salads), but also via chicken salad and milk drinks. High prevalences of *Cryptosporidium* and *Giardia* in veal calves (the age group 1-6 weeks) have been reported (Van der Giessen et al., 2003). However, in this study, all isolates from the former group belonged to the pathogenic *Cryptosporidium parvum* genotype 2, whilst only few isolates from the latter group showed similarities with *Giardia* isolates from humans. Other authors also reported presence of these protozoan parasites, *Cryptosporidium* (de Visser et al., 1987) and *Giardia* (Trullard 2002; McDonough et al., 1994) in veal calves.

11.7. Risk evaluation and principles of food safety assurance at calf farm level

The prevalence-level of infection and/or contamination of calves with, and further spread of, foodborne pathogens at calf farms depend on a large number of risk factors that are inherently variable even at single-farm level. The complexity of the problem is further exacerbated by the existence of a number of different farming systems for veal calves in the EU; and even within each of the main farming categories (e.g. intensive *vs* extensive) a large number of "epidemiological" subcategories exists that differ with respect to one or more risk factors.

Therefore, presently, both knowledge and published data are insufficient to produce a universal risk assessment enabling quantitative categorization of different types of calf farms and/or their quantitative comparison/ranking with respect to main foodborne pathogens.

Nevertheless, the role of some main factors contributing to an increase in prevalence and/or in levels of foodborne pathogens in food animals on farms (including calves) are reasonably well understood, as are the generic principles of their control. They are indicated in a condensed form in Table 11.1. It is logical that calves from farming systems in which fewer of the contributing factors exist and where the controls are more complete/efficient will represent lower foodborne pathogen-risk than calves from farming systems having opposite contributing factors-controls situation. Therefore, future food safety risk categorization of individual farming system, or related between-systems comparisons, would be dependent upon obtaining and analysing quantitative information on: a) status/levels of contributing factors; b) status/levels of hazards of main concern; and c) existence and effectiveness of their controls.

Table 11.1. Main factors contributing to increased prevalence/levels of foodborne pathogens in calves on farms and principles of their controls

Examples of main contributing factors	Food safety risks	Principles of risk reduction
Microbiologically contaminated feed/pasture	Spread of pathogens to calves via feed including vertical via milk	GFP-GHP*; bactericidal feed treatments; feed quality controls; pasture management controls
Sharing water troughs and/or feeders	Water- and/or feed mediated, horizontal spread of pathogen between calves	GFP-GHP; effective sanitation of water supply; individual watering/feeding systems
Poor floor conditions	Enhanced environmental survival and/or "accumulation" of pathogens in cracks/damages of flooring and their spread in calves	GFP-GHP; smooth and cleanable flooring
Use of dirty bedding	Enhanced environmental survival and/or "accumulation" of pathogens; bedding-mediated spread of pathogens to calves internally or externally (hide contamination)	GFP-GHP; effective cleaning regimes
High humidity, inadequate ventilation	Enhanced environmental survival and/or "accumulation" of pathogens; enhanced airborne spread of pathogens to calves	GFP-GHP; air quality management
Animal stress	Increased susceptibility to, and shedding of, pathogens in calves	Animal welfare assurance; farm quality management
Presence of vectors	Increased on-farm and to-calves spread of pathogens via rodents, insects	GFP-GHP; biosecurity; vector controls
Housing calves in larger groups or insufficient floor space allowance	Increased cross-contamination of calves with pathogens through increased physical contacts	Limited group size in optimal space
Continuous restocking and/or mixing calves from different sources	Increased "importation" and spread of pathogens via animals "asymptomatic excretors"	Animal supply only from known, epidemiologically "equivalent" sources; "all in–all out" system
Presence of animal diseases	Spread of zoonotic agents in calves	Global disease control programmes; heard health plans

**Good Farming Practice-Good Hygiene Practice*

12. Risk assessment

12.1. Introduction to risk assessment approach

When the AHAW Panel of EFSA was confronted with the tasks of updating the 1995 Report (SVC, 1995), the working group members were asked to make it on the basis of a Risk Assessment , and particularly to consider the possible effects on the calf and, where relevant, on food safety. It appeared entirely feasible for the working group members to follow this part of a risk analysis approach where risks were defined as those concerning the welfare of calves.

The risk of concern in this report is that the welfare of the calves will be poor. This may involve an increased risk of injury, of disease, of negative feelings or of failure to cope. The time span of such poor welfare might vary from short to long and severity can vary from low to high.

A member experienced in risk assessment procedures was included in the working group from the start. Initially, the procedure adopted for the risk assessment was identified and presented to the participants of the whole working group.

When identifying the hazards, it has been assumed that the managers of the farm and animal keepers have a basic knowledge, that they have undergone training, that they are aware that the particular constraints on the farm do not hamper their work (e.g. lack of facilities on a farm). However, it is pointed out that under practical conditions hazards may interact, e.g. inadequate air flow may interact with poor air quality, inadequate clinical health monitoring may interact with inadequate haemoglobin monitoring, etc.

The identification of hazards and consequential risks to welfare, as well as the risk assessment approach, were agreed by the working group.

12.2. Steps of the risk assessment

A. Multidisciplinary approach

The expert working group it was selected on the basis of having expertise in animal science, ethology, veterinary medicine, risk assessment and food safety.

B. Listing of potential hazards, hazard characterization and exposure assessment

The first step was to describe the needs of calves (see chapter 7 and listed below). Then, 36 hazards that might compromise those needs were identified (Table 12.2) and related to each specific need (Table 12.3). The hazards were characterized in relation to the impact they have on the animal. The exposure to the hazard might vary between different rearing systems. For this purpose a set of different rearing categories was developed (Table 12.1) as well as scoring categories for the hazard characterisation, exposure assessment and risk evaluation (Table 12.4).

Table 12.1. Rearing categories considered in the Risk Assessment

Animal Type	Rearing Category
Veal	A.a. White veal in small groups, bucket fed (i.e. not suckling)
	A.b. White veal in larger groups with automatic feeding system (i.e. not suckling)
	A.c. Pink veal in small groups, bucket fed + solid foods[4], not suckling
	A.d. White veal in small groups, suckling
Replacement Dairy Calves	B.a. Small groups, bucket fed (not suckling) + solid foods, weaned at 2 - 3 months
	B.b. Groups with an automatic feeding system (not suckling) + solid foods, weaned at 2-3 months
	B.c. Feed lots (high density groups within outside pens)
	B.d. Hutches outside, bucket fed (not suckling) + solid foods, weaned at 2-3 months
Beef Calves	C.a. Suckler calves in small groups kept inside, led twice a day to the dam for suckling up to 6-9 months

The hazards were identified and characterized, as well as, an estimate of the probable exposure. However, to ensure that these estimates of exposure correspond with current practice in various European calf production systems, a group of veterinarians, experts in clinical practice in calf production, named the "**Consultation Group**", was identified. Criteria for invitation were the following; predominantly engaged in clinical practice; extensive clinical experience in calf medicine; and covering various geographical areas where calf production is significant in the EU. Another important criterion was that the consultant should not be affiliated with the calf production industry. In total 7 veterinarians accepted an invitation to assist in the exposure assessment. The experience of the individuals covered the various husbandry systems and important veal producing countries in Europe. The consultation group prompted that for the exposure assessment, a quintile distribution (i.e. five classes of 20% increments) of exposure classes be adopted. In some instances the estimates of the WG and the Consultation Group on exposure did not agree in which case the opinion of the Consultation Group was interpreted to represent the factual situation. In other instances the exposure could not be estimated due to lack of data, in which cases the risks were labelled "uncertain". For hazards characterized as moderately to very serious, this uncertainty is highlighted. Table 1 in Annex 1 show the agreed scoring between the WG Members and the "Consultation Group" for the hazard characterisation, exposure assessment and risk evaluation.

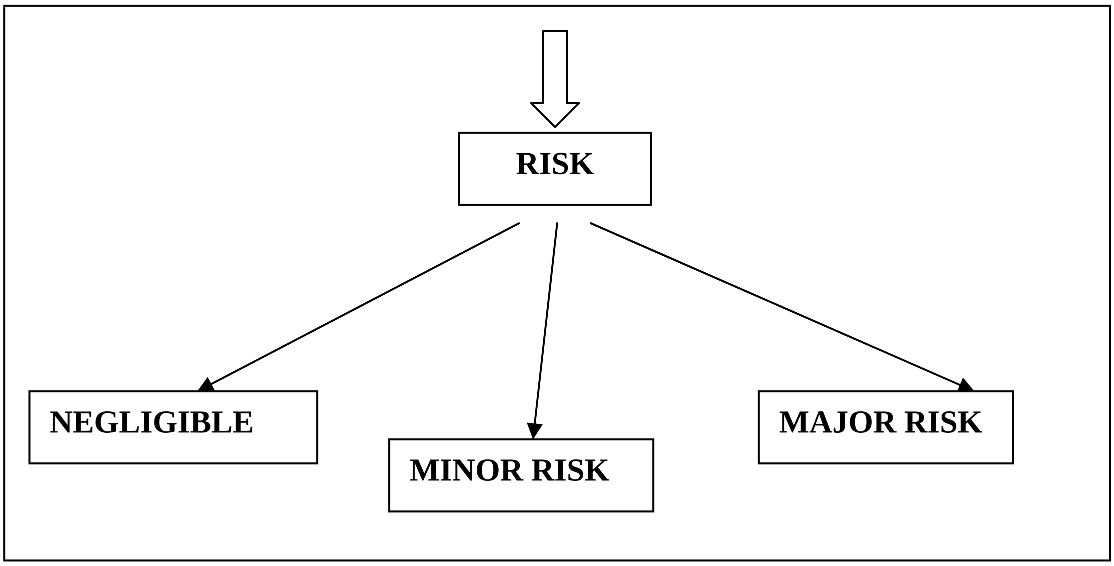
[1] Categories in present hazard characterisation tables are indicated in bold

[2] Solid foods in larger quantitites than for white veal calves

RISK ASSESSMENT

- Hazard identification
- Hazard characterization ("impact")
- Exposure assessment ("frequency of occurrence")

Identify hard facts research data and where they are missing.



NEEDS OF CALVES

1. To breathe
2. To rest and sleep
3. To exercise
4. To avoid fear
5. To feed and drink
    - 5.1. Sucking
    - 5.2. Drinking
    - 5.3. Rumination
    - 5.4. Feed manipulation
6. To obtain nutrients
    - 6.1. Feed
    - 6.2. Water
7. Normal gut development
8. To explore
9. Social contact

9.1. Maternal contact

9.2. Other animal contacts

10. To minimise injury and disease

10.1. Gastrointestinal

10.2 Respiratory

10.3 Injuries

10.4. Other

11. To groom

12. Thermoregulation

12.1. Selection of location

12.2. Body position

12.3. Water drinking

13. To avoid harmful chemical agents

14. To avoid pain and discomfort

Table 12.2. List of Hazards considered in the Risk Assessment

HAZARDS REFERRING TO	HAZARD
NUTRITION	1a) Inadequate colostrum intake - quantity
	1b) Inadequate colostrum intake – quality
	1c) Inadequate colostrum intake – duration
	2) Iron deficiency resulting in Haemoglobin levels below 4.5 mmol/l
	3) Deficiency of other minerals (Cu, Se)
	4) Insufficient access to water (not milk) (especially during warm season)
	5) Allergenic proteins
	6) Insufficient appropriately balanced solid food
	7) Overfeeding (Too rich diet)
	8) Underfeeding
	9) Too low temperature of milk or milk replacer
	10) Exposure to excessively contaminated feed that results in pathology
	11) No access to natural teat or artificial teat
HOUSING	12) High humidity and too high or low a temperature
	13) Indoor draughts
	14) Inadequate ventilation, inappropriate airflow, and air distribution within the house, airspeed, temperature
	15) Poor air quality (ammonia, bio-aerosols and dust))
	16) Poor air quality (H_2S)
	17) Poor insulation against cold
	18) Poor floor conditions a) Gap too large b) Too abrasive c) Too slippery d) Too dirty e) Wet floor for lying f) No bedding
	19) Given that bedding is used: soiled bedding
	20) Insufficient floor space allowance
	21) Insufficient light for response to visual stimuli
	22) Barren environment, lack of stimuli, tactile, visual, etc..
	23) Social isolation
	24) Exposure to pathogens causing respiratory and gastrointestinal disorders
MANAGEMENT	25) Rough handling on the farm
	26) Inadequate clinical health monitoring
	27) Inadequate haemoglobin monitoring
	28) Continuous restocking No “all in - all out” policy
	29) Poor response of farmer to health problems, especially necessary dietary changes
	30) With holding necessary veterinary therapeutic health care, poor preventative medicine programme e.g. vaccination
	31) Lack of maternal care
	32) Mixing calves from different sources
	33) Insufficient contact with humans
	34) Poorly educated stockperson, poor attitude
	35) Castration and dehorning without anaesthetics drugs and an adequate post-operative analgesia regime
	36) Separation from the dam

Table 12.3. List of Hazards related to needs impaired

HAZARDS REFERRING TO	HAZARD	NEEDS (NUMBERED) IMPAIRED
NUTRITION	1) Inadequate colostrum intake	5.1., 10.1; 10.2;
	2) Iron deficiency resulting in Haemoglobin levels below 4.5 mmol/l	3, 6.1, 10
	3) Deficiency of other minerals (Cu, Se)	3, 6.1, 10
	4) Insufficient access to water (not milk) (especially during warm season)	5, 6.2,, 10,4, 12.3
	5) Allergenic proteins	6.1, 7, 10
	6) Insufficient appropriately balanced solid food	5.3, 5.4, 6.1, 7
	7) Too rich diet (overfeeding)	6.1, 10.1,
	8) Underfeeding	6.1, 10,12
	9) Too low temperature of milk or milk replacer	6.1, 10.1, 12
	10) Exposure to excessively contaminated feed that results in pathology	2, 3, 5, 9, 10
	11) No access to natural teat or artificial teat	5.1, 10
HOUSING	12) High humidity	5.4, 6.1, 7, 10, 12.1, 12.2
	13) Indoor draughts	2, 7, 10, 12.1,12.2, 12.3,
	14) Inadequate ventilation, Inappropriate airflow, airspeed, temperature	2, 5.1, 10, 12.1, 12.2, 12.3
	15) Poor air quality (ammonia, bio-aerosols and dust))	1, 2, 5.4, 6.1, 7, 10.2, 13, 14
	16) Poor air quality (H_2S)	1, 2, 5.4, 6.1, 7, 10.2, 13, 14
	17) Poor insulation against cold	6, 10, 12.1, 12.2
	18) Poor floor conditions a) Gap too large b) Too Abrasive c) Too Slippery d) Too Dirty e) Wet floor for lying f) No bedding	2, 3, 5, 6, 8, 10.3, 12, 12.1, 12.2, 14
	19) Given that bedding is used: soiled bedding	2, 10.1, 10.2, 12,2,13
	20) Insufficient floor space allowance	2, 3, 5, 8, 9, 10, 11, 12.2
	21) Insufficient light for response to visual stimuli	3, 4, 5, 8, 9
	22) Barren environment, lack of stimuli, tactile, visual, etc..	3, 8, 9, 10, 12
	23) Social isolation	9
	24) Exposure to pathogens causing respiratory and gastrointestinal disorders	10

MANAGEMENT	25) Rough handling on the farm	3, 4, 9.2, 14
	26) Inadequate clinical health monitoring	10
	27) Inadequate haemoglobin monitoring	3, 6.1, 10
	28) Continuous restocking No “all in - all out” policy	4, 9,2, 10
	29) Poor response of farmer to health problems, especially necessary dietary changes	10
	30) With holding necessary veterinary therapeutic health care, poor health and welfare plan	3 ,5 ,8, 10,
	31) Lack of maternal care	4, 6, 9.1, 9.2
	32) Mixing calves from different sources	4, 5, 9, 10,
	33) Insufficient contact with humans	4
	34) Poorly educated stockperson	4, 5, 6, 10, 12, 13, 14
	35) Castration and dehorning without anaesthetic and analgesic drugs and poor regimes to ensure good pain control	14
	36) Separation from the dam	4, 9.1

Table 12.4. Scoring categories used for the Hazard characterisation, exposure assessment and risk evaluation

Evaluation	Code	Explanation
Hazard characterisation	**SA**	**Slight Adverse Effect**
	AE	**Adverse Effect**
	MS	**Moderately Serious**
	SE	**Serious**
	VS	**Very Serious**
Exposure assessment	**VR**	**Very rare (1 to 20%)[1]**
	RA	**Rare (21 to 40%)**
	MF	**Moderately Frequent (41 to 60%)**
	FR	**Frequent (61 to 80%)**
	VF	**Very Frequent (81 to 100)**
Risk	**NG**	**Negligible**
	mr	**Minor risk**
	MR	**Major Risk**

[1]; 0 is considered not applicable

C. **Assessment of whether hazards pose risks (substantiation by scientific evidence)**

As a consequence of the hazard characterisation and exposure assessment, the risk for poor animal welfare and health was assessed by integrating the hazard character with exposure according to the Table 12.5 below.
The risk was assessed as "Major" if the hazard was judged to have a very serious effect and the exposure was frequent or very frequent or if the hazard was serious and exposure was very frequent. The risk was assessed to be "minor" if the hazard was very serious and exposure was rare, if hazard was moderately serious and exposure was moderately frequent or if hazard was adverse and exposure was very frequent.

Table 12.5. Risk assessment

	Very rare (1-20%)	Rare (21-40)	Moderately frequent (41-60%)	Frequent (61-80%)	Very frequent (81-100%)
Slight adverse effect	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Negligible risk
Adverse effect	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Minor risk
Moderately serious effect	Negligible risk	Negligible risk	Minor risk	Minor risk	Minor risk
Serious effect	Negligible risk	Negligible risk	Minor risk	Minor risk	Major risk
Very serious effect	Negligible risk	Minor risk	Minor risk	Major risk	Major risk

12.3. Risks for poor calf health and welfare

<u>**Risk assessment**</u>

The following major and minor risks for poor animal health and welfare have been identified for the various husbandry systems:

Major risks

1c) Inadequate colostrum intake – duration
A.a., A.b., A.c., B.a., B.b., B.c., B.d.
14) Inadequate ventilation, inappropriate airflow, airspeed temperature
A.a., A.b., A.c., A.d., B.a., B.b.
24) Exposure to pathogens causing respiratory and gastrointestinal disorders
A.a., A.b., B.c.
28) Continuous restocking (No "all in – all out")
B.a., B.b.
32) Mixing calves from different sources
A.a., A.b., A.c., B.c.

Minor risks

1a) Inadequate colostrum intake – quantity
A.a., A.b., A.c., A.d., B.a., B.b., B.c., B.d., C.a.

1b) Inadequate colostrum intake – quality
A.a., A.b., A.c., A.d., B.a., B.b., B.c., B.d., C.a.
4) Insufficient access to water
A.a., A.b., A.d.
6) Insufficiently balanced solid food
A.a., A.b., A.d., C.a.
12) High humidity
A.a., A.b., A.c., A.d.
13) Indoor draughts
A.a., A.b., A.c., A.d.
14) Inadequate ventilation, inappropriate airflow, airspeed temperature
C.a.
15) Poor air quality (ammonia, bioaerosols and dust)
A.b., B.b.
18) Poor floor conditions;
a) gaps too large
A.a., A.b., A.c., A.d., B.a., B.b., C.a.
c) too slippery,
A.a., A.b., A.c., A.d.
e) wet floor for lying,
A.a., A.b., A.c., A.d.
f) no bedding
A.a., A.b., A.c., A.d.
21) Insufficient light for response to visual stimuli
A.a., A.b., A.c., A.d.
24) Exposure to pathogens causing respiratory and gastrointestinal disorders
A.c., A.d., B.a., B.b., C.a.
29) Poor response of farmer to health problems, especially necessary dietary changes
A.a., A.b., A.c., A.d.
31) Lack of maternal care
A.a., A.b., A.c., B.a., B.b., B.c., B.d.
36) Separation from the dam
A.a., A.b., A.c., B.a., B.b., B.c., B.d.

Lack of data
For the following hazards there is not enough data available to assess the risks:

2) Iron deficiency resulting in haemoglobin levels below 4.5 mmol/l
A.a., A.b.
5) Allergenic proteins
A.a., A.b., A.c., A.d., B.a., B.b., B.c., B.d., C.a.
7) Too rich diet (overfeeding)
A.a., A.b., A.c., A.d., B.a., B.b., B.c., B.d., C.a.
20) Insufficient floor space allowance
A.a., A.b., A.c., A.d.
26) Inadequate health monitoring
A.a., A.b., A.c., A.d., B.a., B.b., B.c., B.d., C.a.
27) Inadequate haemoglobulin monitoring
A.a., A.b., A.c., A.d.

Comments

The hazards of iron deficiency and insufficient floor space is considered to be very serious, the hazard of inadequate health monitoring is considered to be serious and the hazards of exposure to inadequate hemoglobin monitoring, allergenic proteins and too rich diet is considered to be moderately serious. For these hazards, there is not enough information on the exposure of calves mainly due to lack of data why it is recommended that further studies should be made to provide evidence for an exposure assessment.

Regarding the hazard 35) Castration and dehorning without anesthetic and analgesic drugs, there is a variation in relation to national legislation as to why the risk of poor welfare in relation to castration and dehorning is widely different between countries. Further, there is a variation in the use of analgesia during the time after the surgery is carried out which also affects the welfare of the calf.

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United Kingdom

17. Annex 1. Hazard characterisation and exposure assessment

Table 1. Hazard characterisation and exposure assessment

Hazard characterisation	Code	Exposure assessment	Code
Slight Adverse Effect	SA	Very rare	VR
Adverse Effect	AE	Rare	RA
Moderately Serious	MS	Moderately Frequent	MF
Serious	SE	Frequent	FR
Very Serious	VS	Very Frequent	VF

HAZARD	HAZARD CHARACTERISATION (impact for individual) Please give score on the line					EXPOSURE ASSESSMENT Probability/frequency of occurrence (population) Please give score on the line				
SCORE	**SA**	**AE**	**MS**	**SE**	**VS**	**VR**	**RA**	**MF**	**FR**	**VF**
NUTRITION										
1a) Inadequate colostrum intake - quantity										
A.a. White veal in small groups, not suckling					X			X		
A.b. White veal in larger groups with automatic feeding system					X			X		
A.c. Pink veal in small groups					X			X		
A.d. White veal in small groups, suckling					X		X			
B.a. Small Groups (RDC)					X			X		
B.b. Groups with an automatic feeding system					X			X		
B.c. Feed lots (high density groups within outside pens)					X			X		

B.d. Hutches outside					X			X		
C.a. Suckler (BC) groups kept inside					X		X			
Comment: Calves are leaving the farm at different ages depending on the country (ie: NL >10 d, IT 1d-1month, FR: 1-2 wk)										

1b) Inadequate colostrum intake- quality										
A.a. White veal in small groups, not suckling					X		X			
A.b. White veal in larger groups with automatic feeding system					X		X			
A.c. Pink veal in small groups					X		X			
A.d. White veal in small groups, suckling					X			X		
B.a. Small Groups (RDC)					X		X			
B.b. Groups with an automatic feeding system					X		X			
B.c. Feed lots (high density groups within outside pens)					X		X			
B.d. Hutches outside					X		X			
C.a. Suckler (BC) groups kept inside					X			X		

1c) Inadequate colostrum intake - duration										
A.a. White veal in small groups, not suckling					X				X	
A.b. White veal in larger groups with automatic feeding system					X				X	
A.c. Pink veal in small groups					X				X	
A.d. White veal in small groups, suckling					X	X				
B.a. Small Groups (RDC)					X				X	
B.b. Groups with an automatic feeding system					X				X	
B.c. Feed lots (high density groups within outside pens)					X				X	

B.d. Hutches outside					X				X	
C.a. Suckler (BC) groups kept inside					X	X				

2) Iron deficiency resulting in Haemoglobin levels below 4.5 mmol/l										
A.a. White veal in small groups, not suckling					X	Data not available				
A.b. White veal in larger groups with automatic feeding system					X	Data not available				
A.c. Pink veal in small groups					X	X				
A.d. White veal in small groups, suckling					X	X				
B.a. Small Groups (RDC)					X	X				
B.b. Groups with an automatic feeding system					X	X				
B.c. Feed lots (high density groups within outside pens)					X	X				
B.d. Hutches outside					X	X				
C.a. Suckler (BC) groups kept inside					X	X				
Comment: Aa and Ab Exposure are not assessed because data are not available. WG Members and Field veterinarians suspect that there is a deficiency in a significant proportion of calves										

3) Deficiency of other minerals (Cu, Se)										
A.a. White veal in small groups, not suckling				X			X			
A.b. White veal in larger groups with automatic feeding system				X			X			
A.c. Pink veal in small groups				X			X			
A.d. White veal in small groups, suckling				X			X			
B.a. Small Groups (RDC)				X			X			
B.b. Groups with an automatic feeding				X			X			

system										
B.c. Feed lots (high density groups within outside pens)				X			X			
B.d. Hutches outside				X			X			
C.a. Suckler (BC) groups kept inside				X			X			

4) Insufficient access to water (not milk) (especially during warm season)										
A.a. White veal in small groups, not suckling				X				X		
A.b. White veal in larger groups with automatic feeding system				X				X		
A.c. Pink veal in small groups				X		X				
A.d. White veal in small groups, suckling				X				X		
B.a. Small Groups (RDC)				X		X				
B.b. Groups with an automatic feeding system				X		X				
B.c. Feed lots (high density groups within outside pens)				X		X				
B.d. Hutches outside				X		X				
C.a. Suckler (BC) groups kept inside				X		X				
Comment: Country differences on insufficient water (no legislation or different legislation between countries). This hazard does not take into account insufficient access to water when there is clinical disease (e.g. diarrhoea). Calves between birth and 5 weeks, suffer from insufficient water depending on countries										

5) Allergenic proteins										
A.a. White veal in small groups, not suckling			X			Data not available				
A.b. White veal in larger groups with automatic feeding system			X							
A.c. Pink veal in small groups			X							

A.d. White veal in small groups, suckling			X			
B.a. Small Groups (RDC)			X			
B.b. Groups with an automatic feeding system			X			
B.c. Feed lots (high density groups within outside pens)			X			
B.d. Hutches outside			X			
C.a. Suckler (BC) groups kept inside			X			
Comment: The recipes of the feed industry frequently change and information is not made available						

6) Insufficent appropriately balanced solid food										
A.a. White veal in small groups, not suckling			X					X		
A.b. White veal in larger groups with automatic feeding system			X					X		
A.c. Pink veal in small groups			X				X			
A.d. White veal in small groups, suckling			X					X		
B.a. Small Groups (RDC)			X							
B.b. Groups with an automatic feeding system			X							
B.c. Feed lots (high density groups within outside pens)			X			Large variation				
B.d. Hutches outside			X							
C.a. Suckler (BC) groups kept inside			X					X		
Comment: Ba, Bb, Bc, Bd: A lot of variation depending on farms, management systems and feeding routines.										

7) Too rich diet (overfeeding*)										
A.a. White veal in small groups, not suckling			X							
A.b. White veal in larger groups with automatic feeding system			X							
A.c. Pink veal in small groups			X							
A.d. White veal in small groups, suckling			X							
B.a. Small Groups (RDC)			X			Data not available				
B.b. Groups with an automatic feeding system			X							
B.c. Feed lots (high density groups within outside pens)			X							
B.d. Hutches outside			X							
C.a. Suckler (BC) groups kept inside			X							
Comment: *overfeeding may occur and diarrhoea might be a consequence										

8) Underfeeding*										
A.a. White veal in small groups, not suckling				X		X				
A.b. White veal in larger groups with automatic feeding system				X			X			
A.c. Pink veal in small groups				X			X			
A.d. White veal in small groups, suckling				X			X			
B.a. Small Groups (RDC)				X		X				
B.b. Groups with an automatic feeding system				X			X			
B.c. Feed lots (high density groups within				X			X			

outside pens)										
B.d. Hutches outside				X			X			
C.a. Suckler (BC) groups kept inside				X			X			
Comment: *underfeeding is to receive insufficient nutrients for maintenance and growth.										
9) Too low a temperature of milk or milk replacer										
A.a. White veal in small groups, not suckling			X			X				
A.b. White veal in larger groups with automatic feeding system			X			X				
A.c. Pink veal in small groups			X			X				
A.d. White veal in small groups, suckling			X			X				
B.a. Small Groups (RDC)			X			X				
B.b. Groups with an automatic feeding system			X			X				
B.c. Feed lots (high density groups within outside pens)			X			X				
B.d. Hutches outside			X			X				
C.a. Suckler (BC) groups kept inside			X			X				

10) Exposure to excessively contaminated feed that results in pathology										
A.a. White veal in small groups, not suckling					X	X				
A.b. White veal in larger groups with automatic feeding system					X	X				
A.c. Pink veal in small groups					X	X				
A.d. White veal in small groups, suckling					X	X				
B.a. Small Groups (RDC)					X	X				
B.b. Groups with an automatic feeding					X	X				

system										
B.c. Feed lots (high density groups within outside pens)					X	X				
B.d. Hutches outside					X	X				
C.a. Suckler (BC) groups kept inside					X	X				

11) No access to natural teat or artificial teat										
A.a. White veal in small groups, not suckling	X								X	
A.b. White veal in larger groups with automatic feeding system	X				X					
A.c. Pink veal in small groups	X				X					
A.d. White veal in small groups, suckling	X				X					
B.a. Small Groups (RDC)	X						X			
B.b. Groups with an automatic feeding system	X				X					
B.c. Feed lots (high density groups within outside pens)N	X					X				
B.d. Hutches outside	X						X			
C.a. Suckler (BC) groups kept inside	X				X					

HOUSING										
12) High humidity										
A.a. White veal in small groups, not suckling				X				X		
A.b. White veal in larger groups with automatic feeding system				X				X		
A.c. Pink veal in small groups				X				X		
A.d. White veal in small groups, suckling				X				X		
B.a. Small Groups (RDC)				X			X			

B.b. Groups with an automatic feeding system				X		X				
B.c. Feed lots (high density groups within outside pens)				X		X				
B.d. Hutches outside				X		X				
C.a. Suckler (BC) groups kept inside				X			X			
Comment: This hazard is much related to regional climatic differences.										

13) Indoor draughts										
A.a. White veal in small groups, not suckling			X					X		
A.b. White veal in larger groups with automatic feeding system			X					X		
A.c. Pink veal in small groups			X					X		
A.d. White veal in small groups, suckling			X					X		
B.a. Small Groups (RDC)			X			X				
B.b. Groups with an automatic feeding system			X			X				
B.c. Feed lots (high density groups within outside pens)			X			Not applicable				
B.d. Hutches outside			X			Not applicable				
C.a. Suckler (BC) groups kept inside			X			X				
Comment: Air speed above 0.5 m/s										

14) Inadequate ventilation inappropriate airflow, airspeed, temperature										
A.a. White veal in small groups, not suckling					X				X	
A.b. White veal in larger groups with automatic feeding system					X				X	

A.c. Pink veal in small groups					X				X	
A.d. White veal in small groups, suckling					X				X	
B.a. Small Groups (RDC)					X				X	
B.b. Groups with an automatic feeding system					X				X	
B.c. Feed lots (high density groups within outside pens)					X	Not applicable				
B.d. Hutches outside					X	Not applicable				
C.a. Suckler (BC) groups kept inside					X		X			
Comment: Geographical differences between north (UK, NL, FR cold) and south climates (warmer climates less frequent)										

15) Poor air quality (ammonia, bio-aerosols and dust)										
A.a. White veal in small groups, not suckling				X			X			
A.b. White veal in larger groups with automatic feeding system				X				X		
A.c. Pink veal in small groups				X			X			
A.d. White veal in small groups, suckling				X			X			
B.a. Small Groups (RDC)				X			X			
B.b. Groups with an automatic feeding system				X				X		
B.c. Feed lots (high density groups within outside pens)				X		X				
B.d. Hutches outside				X		X				
C.a. Suckler (BC) groups kept inside				X			X			
Comment: Depending on the bedding. A.a. depends on the manure system (may be more frequent)										

16) Poor air quality (H_2S)										
A.a. White veal in small groups, not suckling					X	X				

A.b. White veal in larger groups with automatic feeding system					X	X				
A.c. Pink veal in small groups					X	X				
A.d. White veal in small groups, suckling					X	X				
B.a. Small Groups (RDC)					X	Not applicable				
B.b. Groups with an automatic feeding system					X	Not applicable				
B.c. Feed lots (high density groups within outside pens)					X	Not applicable				
B.d. Hutches outside					X	Not applicable				
C.a. Suckler (BC) groups kept inside					X	Not applicable				
Comment: H2S might be present through anaerobic activity in manure and released into the air by stirring of the manure										

17) Poor insulation against cold										
A.a. White veal in small groups, not suckling		X				X				
A.b. White veal in larger groups with automatic feeding system		X				X				
A.c. Pink veal in small groups		X				X				
A.d. White veal in small groups, suckling		X				X				
B.a. Small Groups (RDC)		X				X				
B.b. Groups with an automatic feeding system		X				X				
B.c. Feed lots (high density groups within outside pens)		X				X				
B.d. Hutches outside		X				X				
C.a. Suckler (BC) groups kept inside		X				X				
Comment: In regions with cold climate, good insulation is normally provided for.										

18) Poor floor conditions										
➢ **Gap too large**										
A.a. White veal in small groups, not suckling					X		X			
A.b. White veal in larger groups with automatic feeding system					X		X			
A.c. Pink veal in small groups					X		X			
A.d. White veal in small groups, suckling					X		X			
B.a. Small Groups (RDC)					X		X			
B.b. Groups with an automatic feeding system					X		X			
B.c. Feed lots (high density groups within outside pens)					X	Not applicable				
B.d. Hutches outside					X	Not applicable				
C.a. Suckler (BC) groups kept inside					X		X			
➢ **Too abrasive**		X				X				
➢ **Too slippery**[1]										
A.a. White veal in small groups, not suckling				X				X		
A.b. White veal in larger groups with automatic feeding system				X				X		
A.c. Pink veal in small groups				X				X		
A.d. White veal in small groups, suckling				X				X		
B.a. Small Groups (RDC)				X		X				
B.b. Groups with an automatic feeding system				X		X				
B.c. Feed lots (high density groups within outside pens)				X		X				
B.d. Hutches outside				X		X				
C.a. Suckler (BC) groups kept inside				X		X				
➢ **Too dirty**		X						X		

➢ **Wet floor for lying**										
A.a. White veal in small groups, not suckling			X					X		
A.b. White veal in larger groups with automatic feeding system			X					X		
A.c. Pink veal in small groups			X					X		
A.d. White veal in small groups, suckling			X					X		
B.a. Small Groups (RDC)			X			X				
B.b. Groups with an automatic feeding system			X			X				
B.c. Feed lots (high density groups within outside pens)			X				X			
B.d. Hutches outside			X			X				
C.a. Suckler (BC) groups kept inside			X			X				
➢ **NO bedding**										
A.a. White veal in small groups, not suckling			X							X
A.b. White veal in larger groups with automatic feeding system			X							X
A.c. Pink veal in small groups			X						X	
A.d. White veal in small groups, suckling			X							X
B.a. Small Groups (RDC)			X			X				
B.b. Groups with an automatic feeding system			X			X				
B.c. Feed lots (high density groups within outside pens)			X			X				
B.d. Hutches outside			X			X				
C.a. Suckler (BC) groups kept inside			X			x				
Comment: - **Gap too large** .A. a A.b.and A.c. there are differences depending on national legislation. Problem can be prevalent in very young animals.										

- No bedding: There are national differences on A.c. Pink veal (NL: no bedding, UK bedding by Regulation).
A.a. A.b. some straw placed in France (in this case it is considered Frequent)

19) Given that bedding is used: soiled bedding										
A.a. White veal in small groups, not suckled			X			Not applicable*				
A.b. White veal in larger groups with automatic feeding system			X							
A.c. Pink veal in small groups			X							
A.d. White veal in small groups, suckled			X							
B.a. Small Groups (RDC)			X				X			
B.b. Groups with an automatic feeding system			X				X			
B.c. Feed lots (high density groups within outside pens)			X				X			
B.d. Hutches outside			X				X			
C.a. Suckler (BC) groups kept inside			X				X			

Comment: Soiled bedding is bedding in the pen contaminated by faeces accumulation.
*In veal production bedding is not normally used

20) Insufficient floor space allowance										
A.a. White veal in small groups, not suckled					X	Data not available				
A.b. White veal in larger groups with automatic feeding system					X					
A.c. Pink veal in small groups					X					

A.d. White veal in small groups, suckling					X					
B.a. Small Groups (RDC)					X	X				
B.b. Groups with an automatic feeding system					X	X				
B.c. Feed lots (high density groups within outside pens)					X	X				
B.d. Hutches outside					X	X				
C.a. Suckler (BC) groups kept inside					X	X				
Comment: Although there is some data concerning the needs of space for calves (see previous report) the situation has changed due to the increase group housing and more information is needed to make the assessment - White Veal (A): Lack of data on what is really happening in field, in relation on what is needed. - Insufficient space allowance is defined as not enough space in order to fulfill the animal behavioural needs, such as resting postures, locomotion and social interactions.										

21) Insufficient light for response to visual stimuli										
A.a. White veal in small groups, not suckling					X		X			
A.b. White veal in larger groups with automatic feeding system					X		X			
A.c. Pink veal in small groups					X		X			
A.d. White veal in small groups, suckling					X		X			
B.a. Small Groups (RDC)					X	X				
B.b. Groups with an automatic feeding system					X	X				
B.c. Feed lots (high density groups within outside pens)					X	X				
B.d. Hutches outside					X	X				
C.a. Suckler (BC) groups kept inside					X	X				

22) Barren environment, lack of stimuli, tactile, visual etc.										
A.a. White veal in small groups, not suckling		X						X		
A.b. White veal in larger groups with automatic feeding system		X					X			
A.c. Pink veal in small groups		X					X			
A.d. White veal in small groups, suckling		X					X			
B.a. Small Groups (RDC)		X					X			
B.b. Groups with an automatic feeding system		X					X			
B.c. Feed lots (high density groups within outside pens)		X				X				
B.d. Hutches outside		X					X			
C.a. Suckler (BC) groups kept inside		X					X			
Comment: original scoring has been used as it is shown to fit best with the individual scoring of the field vets										

23) Social isolation										
A.a. White veal in small groups, not suckling					X	X				
A.b. White veal in larger groups with automatic feeding system					X	X				
A.c. Pink veal in small groups					X	X				
A.d. White veal in small groups, suckling					X	X				
B.a. Small Groups (RDC)					X	X				
B.b. Groups with an automatic feeding system					X	X				
B.c. Feed lots (high density groups within outside pens)					X	X				

B.d. Hutches outside					X	X				
C.a. Suckler (BC) groups kept inside					X	X				

24) Exposure to pathogens causing respiratory and gastrointestinal disorders										
A.a. White veal in small groups, not suckling					X				X	
A.b. White veal in larger groups with automatic feeding system					X				X	
A.c. Pink veal in small groups					X			X		
A.d. White veal in small groups, suckling					X			X		
B.a. Small Groups (RDC)					X		X			
B.b. Groups with an automatic feeding system					X			X		
B.c. Feed lots (high density groups within outside pens)					X				X	
B.d. Hutches outside					X	X				
C.a. Suckler (BC) groups kept inside					X		X			

MANAGEMENT										
25) Rough handling on the Farm										
A.a. White veal in small groups, not suckling			X			X				
A.b. White veal in larger groups with automatic feeding system			X			X				
A.c. Pink veal in small groups			X			X				
A.d. White veal in small groups, suckling			X			X				
B.a. Small Groups (RDC)			X			X				
B.b. Groups with an automatic feeding			X			X				

system										
B.c. Feed lots (high density groups within outside pens)			X			X				
B.d. Hutches outside			X			X				
C.a. Suckler (BC) groups kept inside			X			X				
Comment: Transport is not considered. National/regional/traditional differences may increase the frequency of occurrence										

26) Inadequate clinical health monitoring										
A.a. White veal in small groups, not suckling				X						
A.b. White veal in larger groups with automatic feeding system				X						
A.c. Pink veal in small groups				X						
A.d. White veal in small groups, suckling				X						
B.a. Small Groups (RDC)				X						
B.b. Groups with an automatic feeding system				X						
B.c. Feed lots (high density groups within outside pens)				X						
B.d. Hutches outside				X						
C.a. Suckler (BC) groups kept inside				X						
Comment: It includes both stockman/farmer and veterinarian monitoring procedures and their implementation.										

27) Inadequate haemoglobin monitoring										
A.a. White veal in small groups, not suckling			X							
A.b. White veal in larger groups with automatic feeding system			X							
A.c. Pink veal in small groups			X							
A.d. White veal in small groups, suckling			X							

B.a. Small Groups (RDC)			X			Not applicable
B.b. Groups with an automatic feeding system			X			Not applicable
B.c. Feed lots (high density groups within outside pens)			X			Not applicable
B.d. Hutches outside			X			Not applicable
C.a. Suckler (BC) groups kept inside			X			Not applicable
Comment: It shall include blood sampling, frequency of monitoring, measures taken, at which animal age, etc. - Opinion differences on what adequate monitoring is. No final conclusion achieved. - Not applicable categories: haemoglobin monitoring is not necessary because production/meat type						

28) Continuous restocking No "all in -all out"										
A.a. White veal in small groups, not suckling				X			X			
A.b. White veal in larger groups with automatic feeding system				X			X			
A.c. Pink veal in small groups				X			X			
A.d. White veal in small groups, suckling				X			X			
B.a. Small Groups (RDC)				X						X
B.b. Groups with an automatic feeding system				X						X
B.c. Feed lots (high density groups within outside pens)				X			X			
B.d. Hutches outside				X		Not applicable				
C.a. Suckler (BC) groups kept inside				X		X				
Comment: It should refer to the building/housing										

29) Poor response of farmer to health problems, especially necessary dietary changes										
A.a. White veal in small groups, not suckling				X				X		
A.b. White veal in larger groups with automatic feeding system				X				X		
A.c. Pink veal in small groups			X					X		
A.d. White veal in small groups, suckling				X				X		
B.a. Small Groups (RDC)			X			X				
B.b. Groups with an automatic feeding system			X			X				
B.c. Feed lots (high density groups within outside pens)			X			X				
B.d. Hutches outside			X			X				
C.a. Suckler (BC) groups kept inside			X			X				

Comment: No real data on this issue is available. However the approach of the clinical field vets was considered
B and C In some places the WG was aware that when over quota milk is fed to replacement calves

30) With holding necessary veterinary therapeutic health care										
A.a. White veal in small groups, not suckling					X					
A.b. White veal in larger groups with automatic feeding system					X					
A.c. Pink veal in small groups					X					
A.d. White veal in small groups, suckling					X					
B.a. Small Groups (RDC)					X					
B.b. Groups with an automatic feeding system					X					
B.c. Feed lots (high density groups within					X					

outside pens)										
B.d. Hutches outside					X					
C.a. Suckler (BC) groups kept inside					X					

Comment: It has been considered difficult to evaluate the exposure due to the farmer behaviour, sometimes trying to do them before calling the veterinary. Also it depends on the value of the animal.
- Considerations were done on when the call was done: never called, called on time or arrived too late.
- The overall evaluation is that <u>0-20 % was not properly done</u> (not call or too late).

31) Lack of maternal care										
A.a. White veal in small groups, not suckling		X								X
A.b. White veal in larger groups with automatic feeding system		X								X
A.c. Pink veal in small groups		X								X
A.d. White veal in small groups, suckling		X				X				
B.a. Small Groups (RDC)		X								X
B.b. Groups with an automatic feeding system		X								X
B.c. Feed lots (high density groups within outside pens)		X								X
B.d. Hutches outside		X								X
C.a. Suckler (BC) groups kept inside		X				X				

32) Mixing calves from different sources										
A.a. White veal in small groups, not suckling					X					X
A.b. White veal in larger groups with automatic feeding system					X					X

A.c. Pink veal in small groups					X					X
A.d. White veal in small groups, suckling					X	X				
B.a. Small Groups (RDC)					X	X				
B.b. Groups with an automatic feeding system					X	X				
B.c. Feed lots (high density groups within outside pens)					X					X
B.d. Hutches outside					X	X				
C.a. Suckler (BC) groups kept inside					X	X				

33) Insufficient contact with humans										
A.a. White veal in small groups, not suckling		X					X			
A.b. White veal in larger groups with automatic feeding system		X					X			
A.c. Pink veal in small groups		X					X			
A.d. White veal in small groups, suckling		X						X		
B.a. Small Groups (RDC)		X				X				
B.b. Groups with an automatic feeding system		X					X			
B.c. Feed lots (high density groups within outside pens)		X							X	
B.d. Hutches outside		X				X				
C.a. Suckler (BC) groups kept inside		X						X		
Comment: With automatic feeding systems there is a learning period involving aproppriate human contact										

34) Poorly educated stockperson										
A.a. White veal in small groups, not suckling			X				X			
A.b. White veal in larger groups with automatic feeding system			X				X			

A.c. Pink veal in small groups			X				X			
A.d. White veal in small groups, suckling			X				X			
B.a. Small Groups (RDC)			X				X			
B.b. Groups with an automatic feeding system			X				X			
B.c. Feed lots (high density groups within outside pens)			X				X			
B.d. Hutches outside			X				X			
C.a. Suckler (BC) groups kept inside			X				X			

35) Castration and dehorning without anaesthetics and analgesic drugs and poor regime to ensure good pain control										
A.a. White veal in small groups, not suckling					X	Not applicable				
A.b. White veal in larger groups with automatic feeding system					X	Not applicable				
A.c. Pink veal in small groups					X	Not applicable				
A.d. White veal in small groups, suckling					X	Not applicable				
B.a. Small Groups (RDC)					X					
B.b. Groups with an automatic feeding system					X					
B.c. Feed lots (high density groups within outside pens)					X					
B.d. Hutches outside					X					
C.a. Suckler (BC) groups kept inside					X					
Comments: Veal calves are not castrated and not dehorned. This may vary according with National Legislation, which is different between countries. Recommendation for need and harmonisation of law on dehorning / castration										

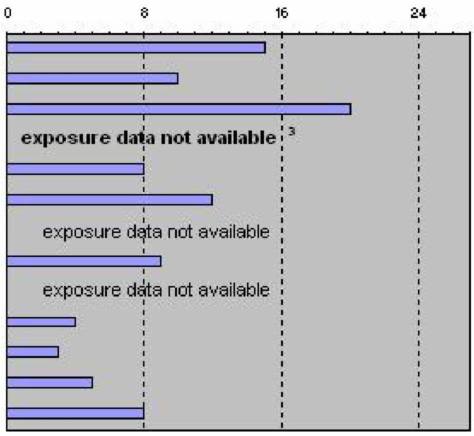
36) Separation from the dam										
A.a. White veal in small groups, not suckling		X								X
A.b. White veal in larger groups with automatic feeding system		X								X
A.c. Pink veal in small groups		X								X
A.d. White veal in small groups, suckling		X				X				
B.a. Small Groups (RDC)		X								X
B.b. Groups with an automatic feeding system		X								X
B.c. Feed lots (high density groups within outside pens)		X								X
B.d. Hutches outside		X								X
C.a. Suckler (BC) groups kept inside			X			X				

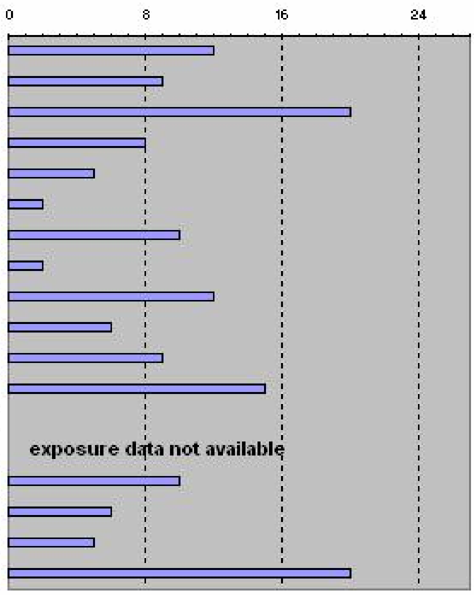
18. Annex 2. Risk characterization scores

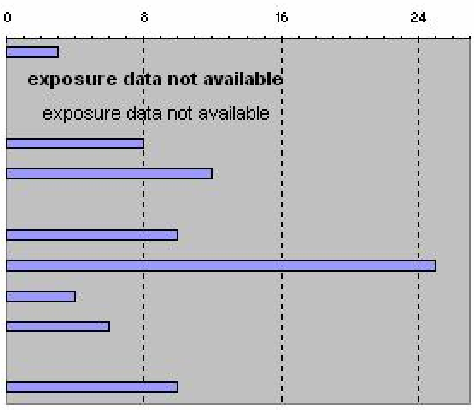
Assessment of risks to welfare of intensively reared calves; subcategory A.a.:

Aa: WHITE VEAL IN SMALL GROUPS, NOT SUCKLING

Associated with		Hazards identified	HC[1]	EA[2]	Risk characterization score (HC x EA)
NUTRITION	◍	Inadequate colostrum intake - quantity	5	3	
	◍	Inadequate colostrum intake - quality	5	2	
	●	Inadequate colostrum intake - duration	5	4	
	?	Iron deficiency (Hb below 4.5 mmol/l)	5		**exposure data not available** [3]
	○	Deficiency of other minerals (Cu, Se)	4	2	
	◍	Insufficient access to water (not milk)	4	3	
	?	Allergenic proteins	3		exposure data not available
	◍	Inappropriately balanced solid food	3	3	
	?	Too rich diet (overfeeding)	3		exposure data not available
	○	Underfeeding	4	1	
	○	Too low temperature of milk / -replacer	3	1	
	○	Exposure to contaminated feed	5	1	
	○	No access to natural of artificial teat	2	4	
HOUSING	◍	High humidity	4	3	
	◍	Indoor draughts	3	3	
	●	Inadequate ventilation	5	4	
	○	Poor air quality (amm., bio-aer., dust)	4	2	
	○	Poor air quality (H2S)	5	1	
	○	Poor insulation against cold	2	1	
	◍	Poor floor conditions, gaps too large	5	2	
	○	Poor floor conditions, too abrasive	2	1	
	◍	Poor floor conditions, too slippery	4	3	
	○	Poor floor conditions, too dirty	2	3	
	◍	Poor floor conditions, wet floor for lying	3	3	
	◍	No bedding	3	5	
	?	Insufficient floor space allowance	5		**exposure data not available**
	○	Insufficient light	5	2	
	○	Barren environment	2	3	
	○	Social isolation	5	1	
	●	Exposure to pathogens	5	4	
MANAGEMENT	○	Rough handling on the farm	3	1	
	?	Inadequate health monitoring	4		**exposure data not available**
	?	Inadequate haemoglobin monitoring	3		exposure data not available
	○	Continuous restocking (no all-in/out)	4	2	
	◍	Poor response to health problems	4	3	
	○	Withholding necessary veterinary care	5		
	◍	Lack of maternal care	2	5	
	●	Mixing calves from different sources	5	5	
	○	Insufficient contact with humans	2	2	
	○	Poorly educated stockperson	3	2	
	◍	Separation from the dam	2	5	







[1] HC = Hazard Characterization

[2] EA = Exposure Assessment

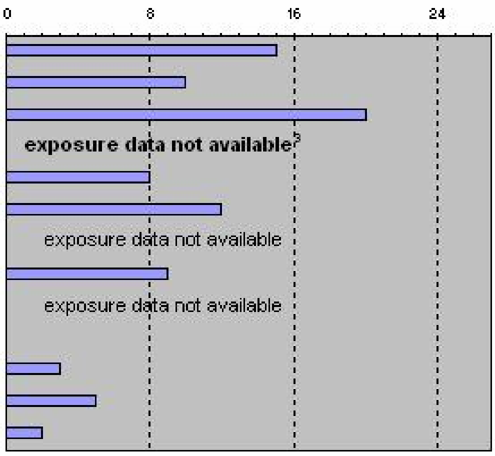
[3] Risk characterization uncertain due to lack of data on exposure. Where indicated in bold, hazards were characterized as moderately to very serious.

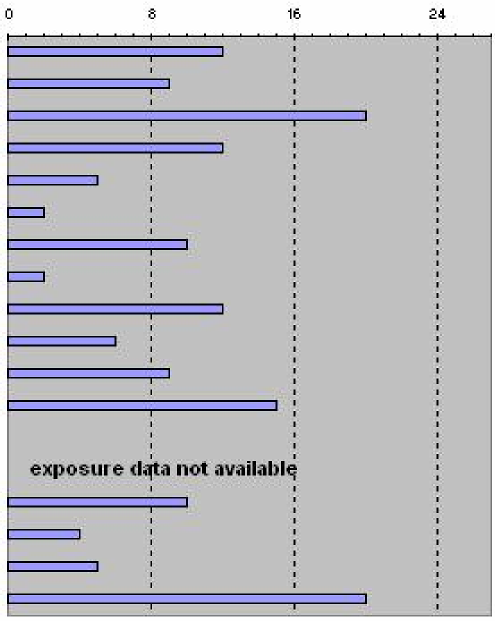
Assessment of risks to welfare of intensively reared calves; subcategory A.b.:

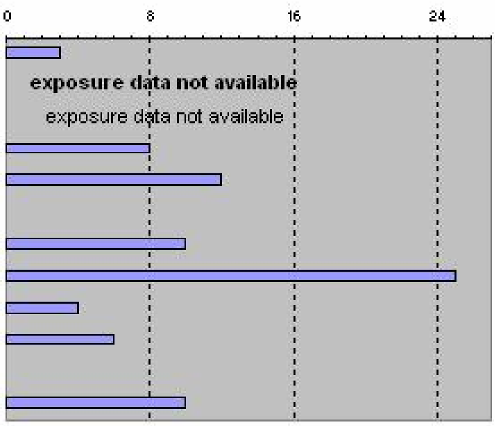
Ab: WHITE VEAL IN LARGER GROUPS, WITH AUTOMATIC FEEDING

Risk characterization score (HC x EA)

Associated with		**Hazards identified**	HC[1]	EA[2]
NUTRITION		Inadequate colostrum intake - quantity	5	3
		Inadequate colostrum intake - quality	5	2
		Inadequate colostrum intake - duration	5	4
	?	Iron deficiency (Hb below 4.5 mmol/l)	5	
		Deficiency of other minerals (Cu, Se)	4	2
		Insufficient access to water (not milk)	4	3
	?	Allergenic proteins	3	
		Inappropriately balanced solid food	3	3
	?	Too rich diet (overfeeding)	3	
		Underfeeding	4	2
		Too low temperature of milk / -replacer	3	1
		Exposure to contaminated feed	5	1
		No access to natural of artificial teat	2	1
HOUSING			HC	EA
		High humidity	4	3
		Indoor draughts	3	3
		Inadequate ventilation	5	4
		Poor air quality (amm., bio-aer., dust)	4	3
		Poor air quality (H2S)	5	1
		Poor insulation against cold	2	1
		Poor floor conditions, gaps too large	5	2
		Poor floor conditions, too abrasive	2	1
		Poor floor conditions, too slippery	4	3
		Poor floor conditions, too dirty	2	3
		Poor floor conditions, wet floor for lying	3	3
		No bedding	3	5
	?	Insufficient floor space allowance	5	
		Insufficient light	5	2
		Barren environment	2	2
		Social isolation	5	1
		Exposure to pathogens	5	4
MANAGEMENT			HC	EA
		Rough handling on the farm	3	1
	?	Inadequate health monitoring	4	
	?	Inadequate haemoglobin monitoring	3	
		Continuous restocking (no all-in/out)	4	2
		Poor response to health problems	4	3
		Withholding necessary veterinary care	5	
		Lack of maternal care	2	5
		Mixing calves from different sources	5	5
		Insufficient contact with humans	2	2
		Poorly educated stockperson	3	2
		Separation from the dam	2	5







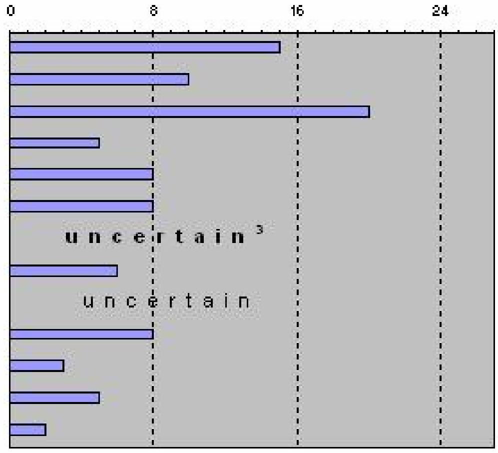
[1] HC = Hazard Characterization
[2] EA = Exposure Assessment
[3] Risk characterization uncertain due to lack of data on exposure.
Where indicated in bold, hazards were characterized as moderately to very serious.

Assessment of risks to welfare of intensively reared calves; subcategory A.c.:

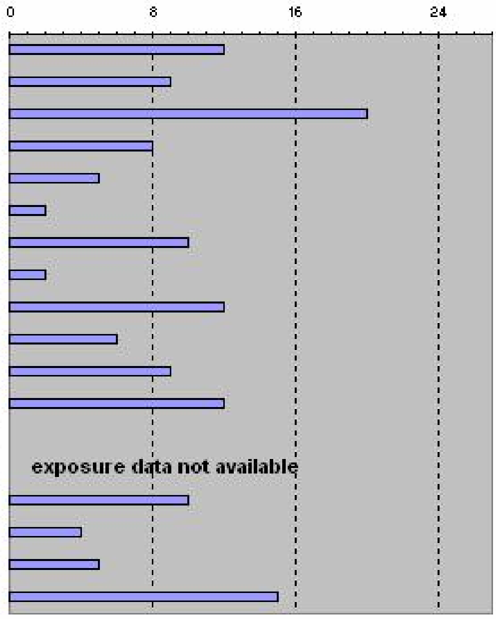
Ac: PINK VEAL IN SMALL GROUPS

Associated with		Hazards identified	HC[1]	EA[2]
NUTRITION	◐	Inadequate colostrum intake - quantity	5	3
	◐	Inadequate colostrum intake - quality	5	2
	●	Inadequate colostrum intake - duration	5	4
	○	Iron deficiency (Hb below 4.5 mmol/l)	5	1
	○	Deficiency of other minerals (Cu, Se)	4	2
	○	Insufficient access to water (not milk)	4	2
	?	Allergenic proteins	3	
	○	Inappropriately balanced solid food	3	2
	?	Too rich diet (overfeeding)	3	
	○	Underfeeding	4	2
	○	Too low temperature of milk / -replacer	3	1
	○	Exposure to contaminated feed	5	1
	○	No access to natural of artificial teat	2	1

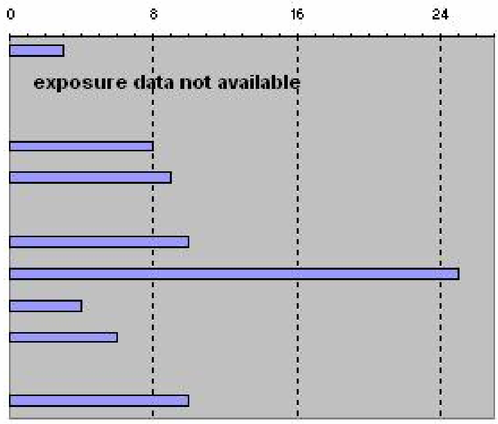
Risk characterization score (HC x EA)



Associated with		Hazards identified	HC	EA
HOUSING	◐	High humidity	4	3
	◐	Indoor draughts	3	3
	●	Inadequate ventilation	5	4
	○	Poor air quality (amm., bio-aer., dust)	4	2
	○	Poor air quality (H2S)	5	1
	○	Poor insulation against cold	2	1
	◐	Poor floor conditions, gaps too large	5	2
	○	Poor floor conditions, too abrasive	2	1
	◐	Poor floor conditions, too slippery	4	3
	○	Poor floor conditions, too dirty	2	3
	◐	Poor floor conditions, wet floor for lying	3	3
	◐	No bedding	3	4
	?	Insufficient floor space allowance	5	
	◐	Insufficient light	5	2
	○	Barren environment	2	2
	○	Social isolation	5	1
	◐	Exposure to pathogens	5	3



Associated with		Hazards identified	HC	EA
MANAGEMENT	○	Rough handling on the farm	3	1
	?	Inadequate health monitoring	4	
	○	Continuous restocking (no all-in/out)	4	2
	◐	Poor response to health problems	3	3
	○	Withholding necessary veterinary care	5	
	◐	Lack of maternal care	2	5
	●	Mixing calves from different sources	5	5
	○	Insufficient contact with humans	2	2
	○	Poorly educated stockperson	3	2
	◐	Separation from the dam	2	5



[1] HC = Hazard Characterization
[2] EA = Exposure Assessment
[3] Risk characterization uncertain due to lack of data on exposure.
Where indicated in bold, hazards were characterized as moderately to very serious.

Assessment of risks to welfare of intensively reared calves; subcategory A.d.:

Ad: WHITE VEAL IN SMALL GROUPS, SUCKLING

Associated with		Hazards identified	HC[1]	EA[2]	Risk characterization score (HC x EA)
NUTRITION		Inadequate colostrum intake - quantity	5	2	
		Inadequate colostrum intake - quality	5	3	
		Inadequate colostrum intake - duration	5	1	
		Iron deficiency (Hb below 4.5 mmol/l)	5	1	
		Deficiency of other minerals (Cu, Se)	4	2	
		Insufficient access to water (not milk)	4	3	
	?	Allergenic proteins	3		exposure data not available [3]
		Inappropriately balanced solid food	3	3	
	?	Too rich diet (overfeeding)	3		exposure data not available
		Underfeeding	4	2	
		Too low temperature of milk / -replacer	3	1	
		Exposure to contaminated feed	5	1	
		No access to natural of artificial teat	2	1	
HOUSING			HC	EA	
		High humidity	4	3	
		Indoor draughts	3	3	
		Inadequate ventilation	5	4	
		Poor air quality (amm., bio-aer., dust)	4	2	
		Poor air quality (H2S)	5	1	
		Poor insulation against cold	2	1	
		Poor floor conditions, gaps too large	5	2	
		Poor floor conditions, too abrasive	2	1	
		Poor floor conditions, too slippery	4	3	
		Poor floor conditions, too dirty	2	3	
		Poor floor conditions, wet floor for lying	3	3	
		No bedding	3	5	
	?	Insufficient floor space allowance	5		**exposure data not available**
		Insufficient light	5	2	
		Barren environment	2	2	
		Social isolation	5	1	
		Exposure to pathogens	5	3	
MANAGEMENT			HC	EA	
		Rough handling on the farm	3	1	
	?	Inadequate health monitoring	4		**exposure data not available**
	?	Inadequate haemoglobin monitoring	3		exposure data not available
		Continuous restocking (no all-in/out)	4	2	
		Poor response to health problems	4	3	
		Withholding necessary veterinary care	5		
		Lack of maternal care	2	1	
		Mixing calves from different sources	5	1	
		Insufficient contact with humans	2	3	
		Poorly educated stockperson	3	2	
		Separation from the dam	2	1	

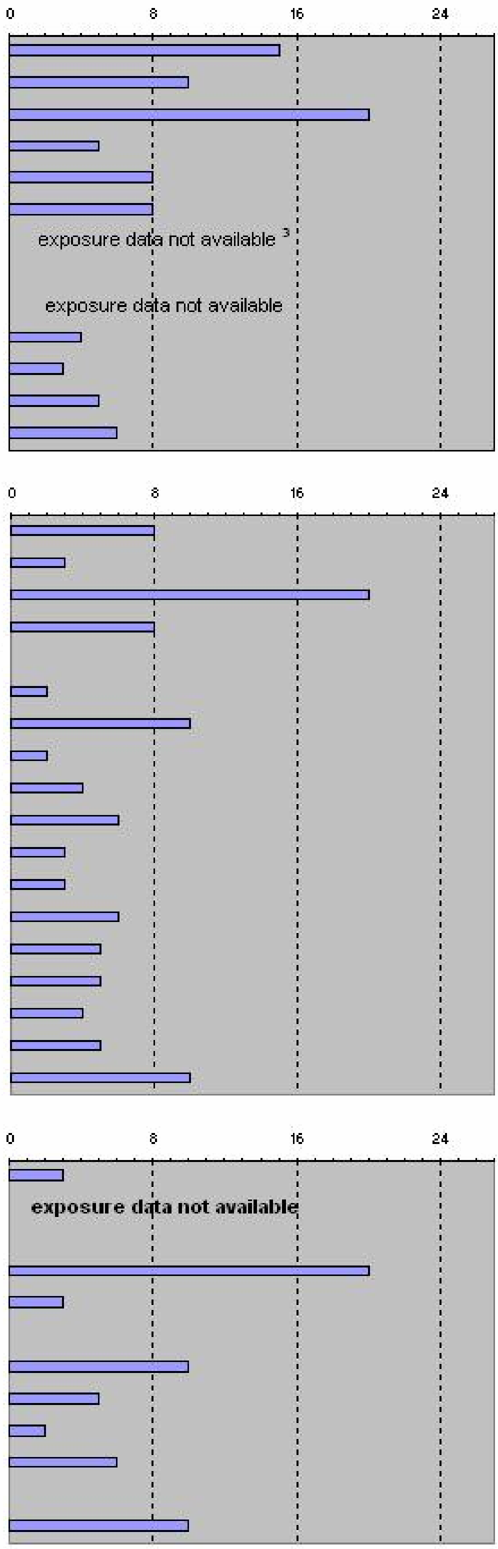
[1] HC = Hazard Characterization
[2] EA = Exposure Assessment
[3] Risk characterization uncertain due to lack of data on exposure.
Where indicated in bold, hazards were characterized as moderately to very serious.

Assessment of risks to welfare of intensively reared calves; subcategory B.a.:

Ba: SMALL GROUPS (RDC)

Associated with		Hazards identified	HC[1]	EA[2]
NUTRITION	◐	Inadequate colostrum intake - quantity	5	3
	◐	Inadequate colostrum intake - quality	5	2
	●	Inadequate colostrum intake - duration	5	4
	○	Iron deficiency (Hb below 4.5 mmol/l)	5	1
	○	Deficiency of other minerals (Cu, Se)	4	2
	○	Insufficient access to water (not milk)	4	2
	?	Allergenic proteins	3	
	○	Inappropriately balanced solid food	3	
	?	Too rich diet (overfeeding)	3	
	○	Underfeeding	4	1
	○	Too low temperature of milk / -replacer	3	1
	○	Exposure to contaminated feed	5	1
	○	No access to natural of artificial teat	2	3
			HC	EA
HOUSING	○	High humidity	4	2
	○	Indoor draughts	3	1
	●	Inadequate ventilation	5	4
	○	Poor air quality (amm., bio-aer., dust)	4	2
	○	Poor insulation against cold	2	1
	◐	Poor floor conditions, gaps too large	5	2
	○	Poor floor conditions, too abrasive	2	1
	○	Poor floor conditions, too slippery	4	1
	○	Poor floor conditions, too dirty	2	3
	○	Poor floor conditions, wet floor for lying	3	1
	○	No bedding	3	1
	○	Soiled bedding (if bedding used)	3	2
	○	Insufficient floor space allowance	5	1
	○	Insufficient light	5	1
	○	Barren environment	2	2
	○	Social isolation	5	1
	◐	Exposure to pathogens	5	2
			HC	EA
MANAGEMENT	○	Rough handling on the farm	3	1
	?	Inadequate health monitoring	4	
	●	Continuous restocking (no all-in/out)	4	5
	○	Poor response to health problems	3	1
	○	Withholding necessary veterinary care	5	
	◐	Lack of maternal care	2	5
	○	Mixing calves from different sources	5	1
	○	Insufficient contact with humans	2	1
	○	Poorly educated stockperson	3	2
	○	Castration/ dehorning, no anaesthetics	5	
	◐	Separation from the dam	2	5

Risk characterization score (HC x EA)



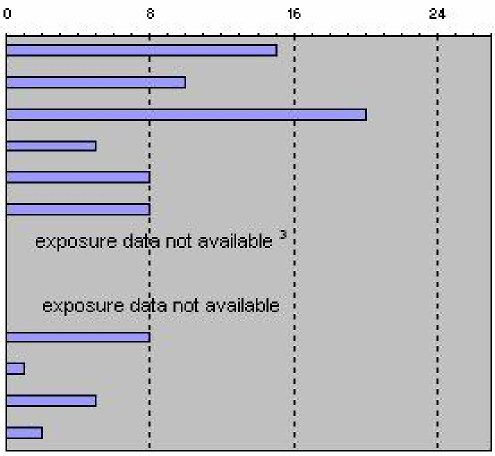
[1] HC = Hazard Characterization
[2] EA = Exposure Assessment
[3] Risk characterization uncertain due to lack of data on exposure.
Where indicated in bold, hazards were characterized as moderately to very serious.

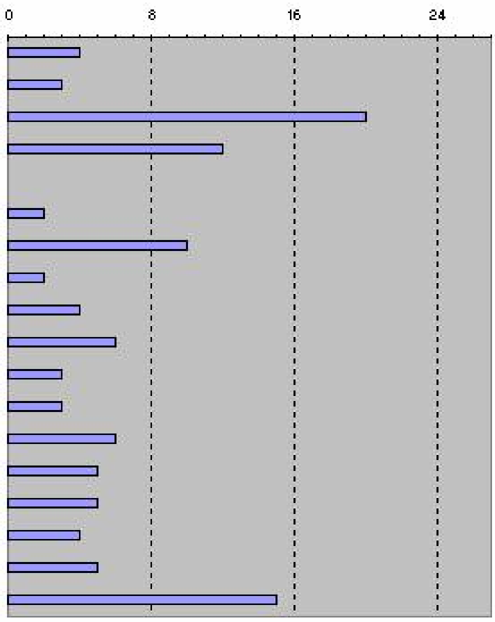
Assessment of risks to welfare of intensively reared calves; subcategory B.b.:

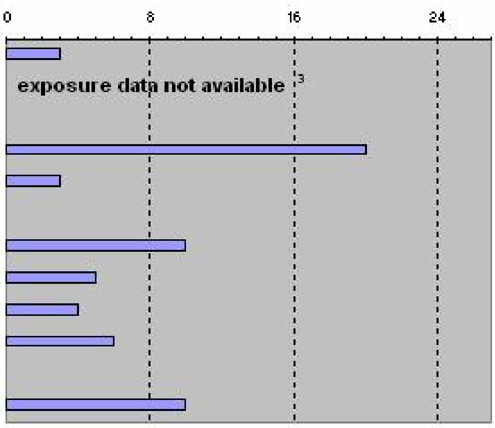
Bb: GROUPS WITH AN AUTOMATIC FEEDING SYSTEM

Associated with		Hazards identified	HC¹	EA²
NUTRITION	◉	Inadequate colostrum intake - quantity	5	3
	◉	Inadequate colostrum intake - quality	5	2
	●	Inadequate colostrum intake - duration	5	4
	○	Iron deficiency (Hb below 4.5 mmol/l)	5	1
	○	Deficiency of other minerals (Cu, Se)	4	2
	○	Insufficient access to water (not milk)	4	2
	?	Allergenic proteins	3	
	○	Inappropriately balanced solid food	3	
	?	Too rich diet (overfeeding)	3	
	○	Underfeeding	4	2
	○	Too low temperature of milk / -replacer	3	1
	○	Exposure to contaminated feed	5	1
	○	No access to natural of artificial teat	2	1
			HC	**EA**
HOUSING	○	High humidity	4	1
	○	Indoor draughts	3	1
	●	Inadequate ventilation	5	4
	◉	Poor air quality (amm., bio-aer., dust)	4	3
	○	Poor insulation against cold	2	1
	◉	Poor floor conditions, gaps too large	5	2
	○	Poor floor conditions, too abrasive	2	1
	○	Poor floor conditions, too slippery	4	1
	○	Poor floor conditions, too dirty	2	3
	○	Poor floor conditions, wet floor for lying	3	1
	○	No bedding	3	1
	○	Soiled bedding (if bedding used)	3	2
	○	Insufficient floor space allowance	5	1
	○	Insufficient light	5	1
	○	Barren environment	2	2
	○	Social isolation	5	1
	◉	Exposure to pathogens	5	3
			HC	**EA**
MANAGEMENT	○	Rough handling on the farm	3	1
	?	Inadequate health monitoring	4	
	●	Continuous restocking (no all-in/out)	4	5
	○	Poor response to health problems	3	1
	○	Withholding necessary veterinary care	5	
	◉	Lack of maternal care	2	5
	○	Mixing calves from different sources	5	1
	○	Insufficient contact with humans	2	2
	○	Poorly educated stockperson	3	2
	○	Castration/ dehorning, no anaesthetics	5	
	◉	Separation from the dam	2	5

Risk characterization score (HC x EA)







¹⁾ HC = Hazard Characterization

²⁾ EA = Exposure Assessment

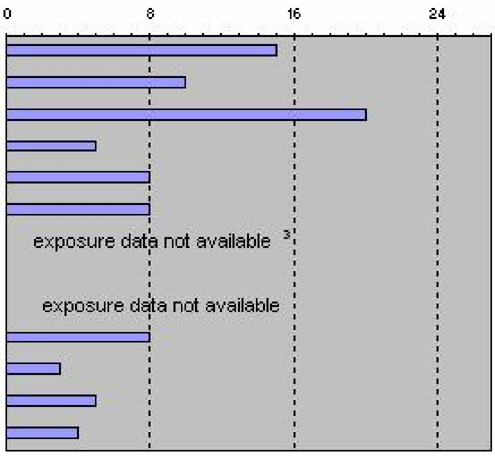
³⁾ Risk characterization uncertain due to lack of data on exposure.

Where indicated in bold, hazards were characterized as moderately to very serious.

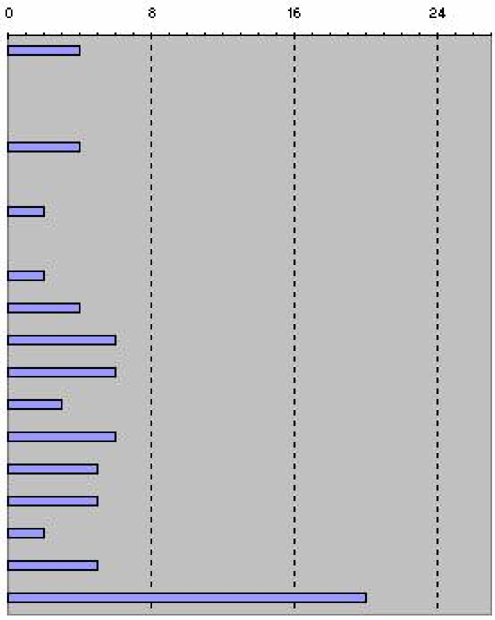
Assessment of risks to welfare of intensively reared calves; subcategory B.c.:

Bc: FEED LOTS (high density groups within outside pens)

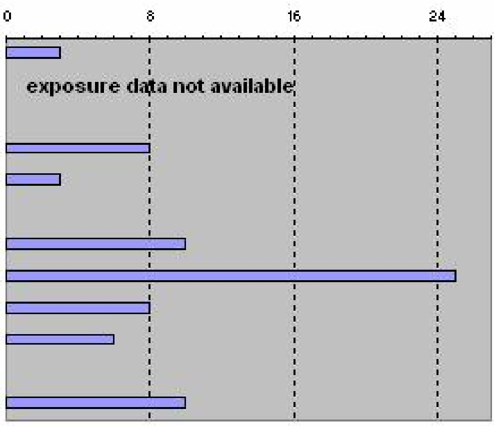
Associated with		Hazards identified	HC[1]	EA[2]	Risk characterization score (HC x EA)
NUTRITION	◍	Inadequate colostrum intake - quantity	5	3	
	◍	Inadequate colostrum intake - quality	5	2	
	●	Inadequate colostrum intake - duration	5	4	
	○	Iron deficiency (Hb below 4.5 mmol/l)	5	1	
	○	Deficiency of other minerals (Cu, Se)	4	2	
	○	Insufficient access to water (not milk)	4	2	
	?	Allergenic proteins	3		exposure data not available [3]
	○	Inappropriately balanced solid food	3		
	?	Too rich diet (overfeeding)	3		exposure data not available
	○	Underfeeding	4	2	
	○	Too low temperature of milk / -replacer	3	1	
	○	Exposure to contaminated feed	5	1	
	○	No access to natural of artificial teat	2	2	



Associated with		Hazards identified	HC	EA	Risk characterization score (HC x EA)
HOUSING	○	High humidity	4	1	
	○	Poor air quality (amm., bio-aer., dust)	4	1	
	○	Poor insulation against cold	2	1	
	○	Poor floor conditions, too abrasive	2	1	
	○	Poor floor conditions, too slippery	4	1	
	○	Poor floor conditions, too dirty	2	3	
	○	Poor floor conditions, wet floor for lying	3	2	
	○	No bedding	3	1	
	○	Soiled bedding (if bedding used)	3	2	
	○	Insufficient floor space allowance	5	1	
	○	Insufficient light	5	1	
	○	Barren environment	2	1	
	○	Social isolation	5	1	
	●	Exposure to pathogens	5	4	



Associated with		Hazards identified	HC	EA	Risk characterization score (HC x EA)
MANAGEMENT	○	Rough handling on the farm	3	1	
	?	Inadequate health monitoring	4		**exposure data not available**
	○	Continuous restocking (no all-in/out)	4	2	
	○	Poor response to health problems	3	1	
	○	Withholding necessary veterinary care	5		
	◍	Lack of maternal care	2	5	
	●	Mixing calves from different sources	5	5	
	○	Insufficient contact with humans	2	4	
	○	Poorly educated stockperson	3	2	
	○	Castration/ dehorning, no anaesthetics	5		
	◍	Separation from the dam	2	5	



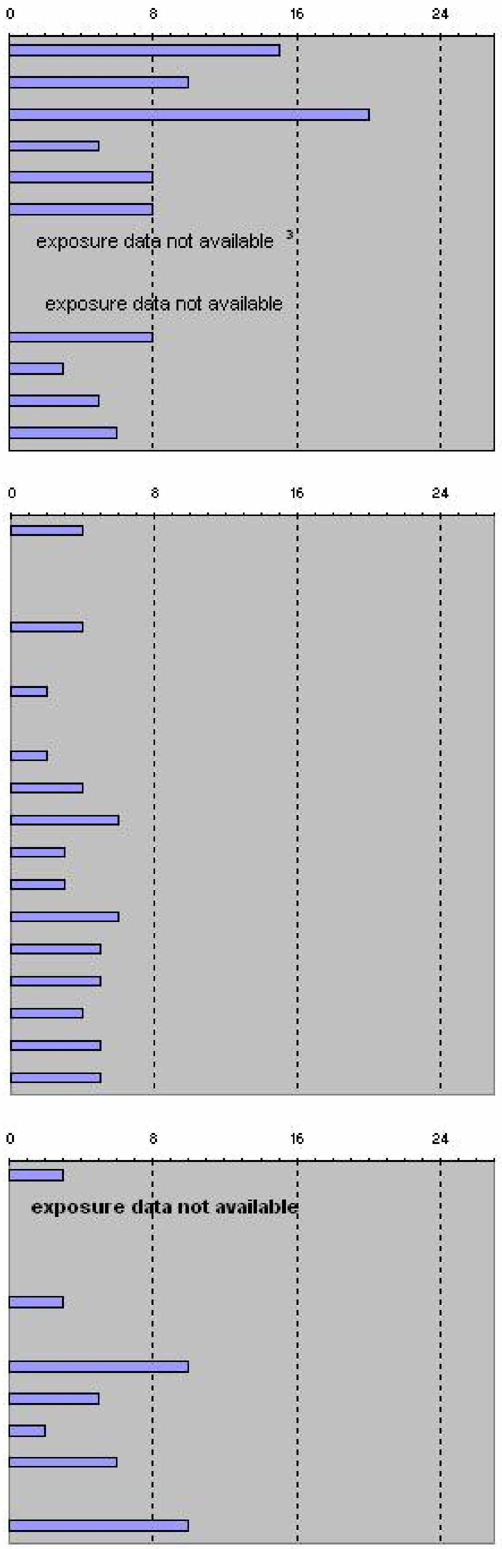
[1] HC = Hazard Characterization
[2] EA = Exposure Assessment
[3] Risk characterization uncertain due to lack of data on exposure.
Where indicated in bold, hazards were characterized as moderately to very serious.

Assessment of risks to welfare of intensively reared calves; subcategory B.d.:

Bd: HUTCHES OUTSIDE

Associated with		Hazards identified	HC[1]	EA[2]
NUTRITION	◉	Inadequate colostrum intake - quantity	5	3
	◉	Inadequate colostrum intake - quality	5	2
	●	Inadequate colostrum intake - duration	5	4
	○	Iron deficiency (Hb below 4.5 mmol/l)	5	1
	○	Deficiency of other minerals (Cu, Se)	4	2
	○	Insufficient access to water (not milk)	4	2
	?	Allergenic proteins	3	
	○	Inappropriately balanced solid food	3	
	?	Too rich diet (overfeeding)	3	
	○	Underfeeding	4	2
	○	Too low temperature of milk / -replacer	3	1
	○	Exposure to contaminated feed	5	1
	○	No access to natural of artificial teat	2	3
HOUSING			HC	EA
	○	High humidity	4	1
	○	Poor air quality (amm., bio-aer., dust)	4	1
	○	Poor insulation against cold	2	1
	○	Poor floor conditions, too abrasive	2	1
	○	Poor floor conditions, too slippery	4	1
	○	Poor floor conditions, too dirty	2	3
	○	Poor floor conditions, wet floor for lying	3	1
	○	No bedding	3	1
	○	Soiled bedding (if bedding used)	3	2
	○	Insufficient floor space allowance	5	1
	○	Insufficient light	5	1
	○	Barren environment	2	2
	○	Social isolation	5	1
	○	Exposure to pathogens	5	1
MANAGEMENT			HC	EA
	○	Rough handling on the farm	3	1
	?	Inadequate health monitoring	4	
	○	Poor response to health problems	3	1
	○	Withholding necessary veterinary care	5	
	◉	Lack of maternal care	2	5
	○	Mixing calves from different sources	5	1
	○	Insufficient contact with humans	2	1
	○	Poorly educated stockperson	3	2
	○	Castration/ dehorning, no anaesthetics	5	
	◉	Separation from the dam	2	5

Risk characterization score (HC x EA)



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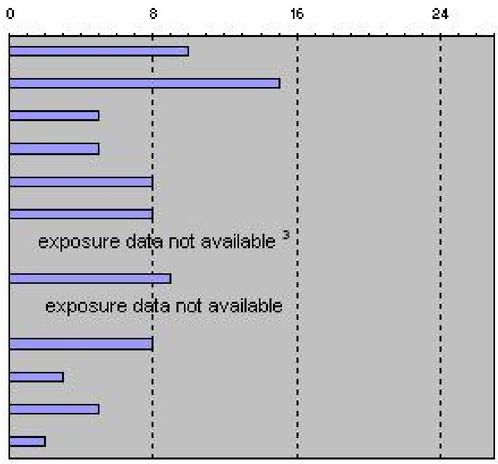
Where indicated in bold, hazards were characterized as moderately to very serious.

Assessment of risks to welfare of intensively reared calves; subcategory C.a.:

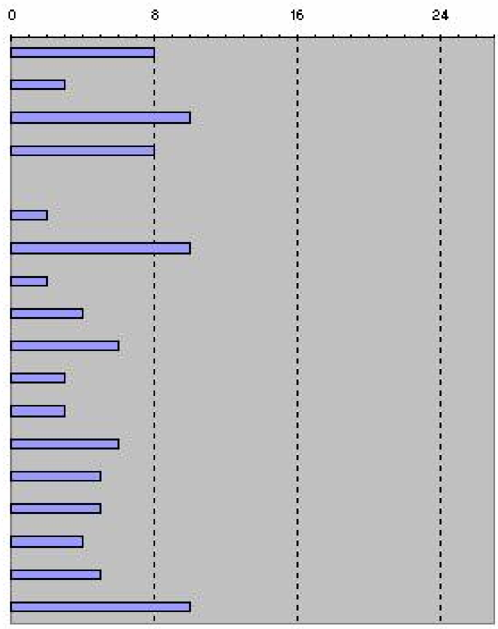
Ca: SUCKLER (BC) GROUPS KEPT INSIDE

Associated with		Hazards identified	HC[1]	EA[2]
NUTRITION	●	Inadequate colostrum intake - quantity	5	2
	●	Inadequate colostrum intake - quality	5	3
	○	Inadequate colostrum intake - duration	5	1
	○	Iron deficiency (Hb below 4.5 mmol/l)	5	1
	○	Deficiency of other minerals (Cu, Se)	4	2
	○	Insufficient access to water (not milk)	4	2
	?	Allergenic proteins	3	
	●	Inappropriately balanced solid food	3	3
	?	Too rich diet (overfeeding)	3	
	○	Underfeeding	4	2
	○	Too low temperature of milk / -replacer	3	1
	○	Exposure to contaminated feed	5	1
	○	No access to natural of artificial teat	2	1

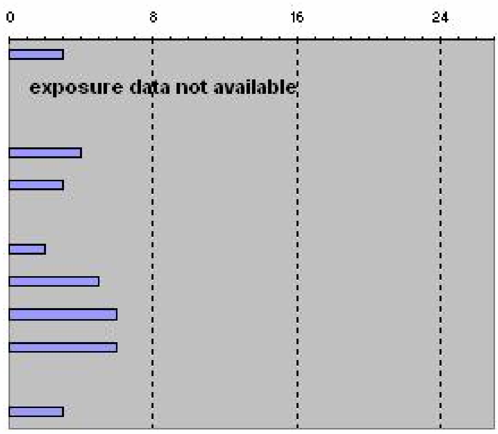
Risk characterization score (HC x EA)



Associated with		Hazards identified	HC	EA
HOUSING	○	High humidity	4	2
	○	Indoor draughts	3	1
	●	Inappropriate ventilation	5	2
	○	Poor air quality (amm., bio-aer., dust)	4	2
	○	Poor insulation against cold	2	1
	●	Poor floor conditions, gaps too large	5	2
	○	Poor floor conditions, too abrasive	2	1
	○	Poor floor conditions, too slippery	4	1
	○	Poor floor conditions, too dirty	2	3
	○	Poor floor conditions, wet floor for lying	3	1
	○	No bedding	3	1
	○	Soiled bedding (if bedding used)	3	2
	○	Insufficient floor space allowance	5	1
	○	Insufficient light	5	1
	○	Barren environment	2	2
	○	Social isolation	5	1
	●	Exposure to pathogens	5	2



Associated with		Hazards identified	HC	EA
MANAGEMENT	○	Rough handling on the farm	3	1
	?	Inadequate health monitoring	4	
	○	Continuous restocking (no all-in/out)	4	1
	○	Poor response to health problems	3	1
	○	Withholding necessary veterinary care	5	
	○	Lack of maternal care	2	1
	○	Mixing calves from different sources	5	1
	○	Insufficient contact with humans	2	3
	○	Poorly educated stockperson	3	2
	○	Castration/ dehorning, no anaesthetics	5	
	○	Separation from the dam	3	1



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Where indicated in bold, hazards were characterized as moderately to very serious.