European Food Safety Authority

The EFSA Journal (2009) 1140, 1-75

Scientific opinion on welfare of dairy cows in relation to metabolic and reproductive problems based on a risk assessment with special reference to the impact of housing, feeding, management and genetic selection[1]

Scientific Opinion of the Panel on Animal Health and Animal Welfare

(Question No EFSA-Q-2008-339)

Adopted on 05 June 2009

This opinion, published on 8 October 2009, replaces the earlier version published on 9 July 2009[2].

PANEL MEMBERS

Bo Algers, Harry J. Blokhuis, Anette Botner, Donald M. Broom, Patrizia Costa, Mariano Domingo, Mathias Greiner, Jörg Hartung, Frank Koenen, Christine Müller-Graf, Raj Mohan, David B. Morton, Albert Osterhaus, Dirk U. Pfeiffer, Ron Roberts, Moez Sanaa, Mo Salman, J. Michael Sharp, Philippe Vannier, Martin Wierup.

SUMMARY

Following a request from the European Commission, the AHAW Panel was asked to deliver a Scientific Opinion on the welfare of dairy cows, considering whether current farming and husbandry systems comply with the requirements of and welfare of dairy cows from the pathological, zootechnical, physiological and behavioural points of view.

Due to the great diversity of topics and the huge amount of scientific data, it was proposed that separate scientific opinions on different welfare subjects would be more adequate and effective. Therefore, it was agreed to subdivide the risk assessment process into four different subjects: i) metabolic and reproductive disorders, ii) udder disorders, iii) leg and locomotion problems and

[1] For citation purposes: Scientific Opinion of the Panel on Animal Health and Welfare on a request from the Commission on the risk assessment of the impact of housing, nutrition and feeding, management and genetic selection on metabolic and reproductive problems in dairy cows. *The EFSA Journal* (2009) 1140, 1-75

[2] The above note has been amended to provide the correct title of the opinion. No further changes have been introduced in the opinion or its annexes. To avoid confusion, the original version of the opinion has been removed from the website, but is available on request as is a version showing all the changes made.

iiii) behaviour, fear and pain. A fifth scientific opinion integrates conclusions and recommendations from the scientific report with the outcomes from the four separate risk assessments.

The scientific opinion on welfare of dairy cows in relation to metabolic and reproductive problems, based on a risk assessment with special reference to the impact of housing, feeding, management and genetic selection, was adopted by the AHAW Panel on 05 June 2009.

In the risk assessment four different farming scenarios were considered: 1) cubicle houses; 2) tie-stalls; 3) straw yards; 4) pasture. Identified hazards were classified under (a) housing, (b) nutrition and feeding, (c) management and (d) genetics. The risk assessment outcomes for each of these four classes of hazards were determined and the four different farming scenarios compared.

When comparing the different farming systems it can be concluded that the risk of suffering metabolic and reproductive disorders is independent of the housing system; however, lower risk estimate values were observed for animals kept at pasture, which may indicate that they are less likely to have metabolic and reproductive problems and therefore poor welfare.

According to the scoring system used in this analysis, the most important hazards in relation to the housing were poor cubicle design and lack of space in cubicle houses and tie-stalls, respectively, with high risk estimate values. Inadequate ventilation, temperature and humidity were the highest ranked hazard in straw yards. However, the risk estimate and magnitude values in straw yards were much lowers than in cubicles and tie-stalls.

Nutrition and feeding related hazards have a major influence on metabolic and reproductive problems defined both in terms of magnitude of the adverse effect and risk estimate. An inadequate transition feeding was the hazard with the highest risk estimates in the three indoor farming systems. Cows are in negative energy balance during early lactation, when functional body tissues may be metabolised to excess, causing poor welfare. This risk is particularly severe in high-producing genetic strains. A transition period feeding that sustains dry matter intake while maintaining optimal body condition at calving reduces this risk. Also, the risk of cow over/under feeding was very high ranked, as well as the risk of an unbalanced diet. Cattle require a diet that is adequate in fibre otherwise the anatomy and physiology of the rumen are impaired and there is increased risk of ruminal acidosis and other related disorders. Unbalanced diet is the major cause of sub-acute ruminal acidosis. Ruminal acidosis (acute and subacute) and parturient paresis (milk fever) can cause very poor welfare in dairy cows. When concentrate dispensers are used, appropriate control is necessary to avoid over/underfeeding and reduce the risk of acute ruminal acidosis. Concentrate feeding facilities on dairy farms should be adequately maintained and diets carefully balanced so as to maintain optimal ruminal fermentation and to minimise negative energy balance.

Reproductive disorders can reflect prolonged or short-term poor welfare, such as lack of oestrus, embryonic loss or early abortion due to stress during parturition and in early lactation, and can also cause poor welfare directly, particularly dystocia and genital infections associated with pain or inflammatory reactions. Among the hazards related to the management of dairy cows, inadequate biosecurity was the highest ranked hazard in all husbandry systems. The magnitude of the adverse effect was the same but in the case of pasture the risk estimate value was lower than on the other three systems. Good hygiene should be provided at calving to reduce risk of genital infections. Improper management was also highly ranked in all farming systems. Recent research shows that a reproductive management strategy with extended calving intervals of 15 months or more seems to offer significant advantages for the welfare of high yielding dairy cows, without reducing overall milk production. To reduce risk of dystocia particularly at first calving, heifers should be inseminated after they reach the mature weight for

the breed and only sires known to have low incidence of dystocia should be used to breed heifers.

Genetic selection for high milk yield with insufficient emphasis on other traits relating to fitness increases the risk of suffering from metabolic and reproductive problems. This risk is greater when housing, nutrition and management are unable to compensate for the adverse effects of genetic selection. The increased inbreeding of recent years may lead to, or be associated with, increased reproductive problems, reduced lifetime milk production and a reduction in breeding performance if it continues. Excessive or prolonged negative energy balance in dairy cows is more likely to occur in the highest producing animals and has been found to be associated with reduced fertility, digestive, metabolic and infectious disease, especially mastitis.

Key words: animal welfare, metabolism, reproduction, dairy cows, risk assessment, housing, nutrition and feeding, management, genetic selection, farming systems.

TABLE OF CONTENTS

BACKGROUND AS PROVIDED BY THE EUROPEAN COMMISSION

Council Directive 98/58/EC concerning the protection of animals kept for farming purposes lays down minimum standards for the protection of animals bred or kept for farming purposes, including cattle, although no specific rules are laid down at Community level for dairy cows. The recently adopted Community Action Plan on the Protection and Welfare of Animals has as one of the main areas of action "upgrading existing minimum standards for animal protection and welfare as well as possibly elaborating specific minimum standards for species or issues that are not currently addressed in EU legislation".

In response to a request from the Commission, EFSA has recently issued a scientific opinion and report on welfare aspects of intensive calf farming systems, updating a report on the welfare of calves adopted by the Scientific Veterinary Committee Animal Welfare Section on 9 November 1995. A scientific opinion on the welfare of cattle kept for beef production was issued by the Scientific Committee on Animal Health and Animal Welfare on 25 April 2001. However no scientific opinion has yet been issued concerning the welfare of dairy cows, except for that on Bovine Somatotrophin (SCAHAW, 1999).

TERMS OF REFERENCE AS PROVIDED BY THE EUROPEAN COMMISSION

Against this background the Commission considers it opportune to request EFSA to issue a scientific opinion on the welfare of dairy cows. This opinion should consider whether current farming and husbandry systems comply with the requirements of the well-being of dairy cows from the pathological, zootechnical, physiological and behavioural points of view. In particular the impact that genetic selection for higher productivity has had on animal welfare should be evaluated, considering inter alia the incidence of lameness, mastitis, metabolic disorders and fertility problems. Where relevant for animal welfare, animal health and food safety aspects should also be taken into account.

Splitting of the Mandate

Due to the great diversity of topics and the huge amount of scientific data, it was proposed that separate scientific opinions on different welfare subjects would be more adequate and effective. The WG Members and the AHAW Panel therefore agreed to initially produce an overall scientific report describing all the hazards identified to be used as a basis for the subsequent risk assessment process which was divided into four different subjects: i) metabolic and reproductive disorders, ii) udder disorders, iii) leg and locomotion problems and iv) behaviour, fear and pain. Since there are some other aspects of poor welfare in dairy cows, in addition to those covered in these four risk assessments, a fifth scientific opinion has also been produced as a global assessment including these aspects. This fifth scientific opinion also integrates conclusions and recommendations from the scientific report with the outcomes from the four separate risk assessments, thus forming an overall summary opinion in response to the mandate.

The list of documents that will be provided to the Commission as a response to the terms of reference of the mandate will be the following:

Scientific Report

"Effects of farming systems on dairy cow welfare and disease"

Scientific Opinion – Udder problems

"Scientific opinion based on a risk assessment of the impact of hazards associated with housing, nutrition and feeding, management and genetic selection on udder problems in dairy cows."

Scientific Opinion - Leg and locomotion problems

"Scientific opinion based on a risk assessment of the impact of hazards associated with housing, nutrition and feeding, management and genetic selection on leg and locomotion problems in dairy cows."

Scientific Opinion - Metabolic and reproductive problems

"Scientific opinion based on a risk assessment of the impact of hazards associated with housing, nutrition and feeding, management and genetic selection on metabolic and reproductive disorders in dairy cows."

Scientific Opinion - Behavioural, fear and pain problems

"Scientific opinion based on a risk assessment of the impact of hazards associated with housing, nutrition and feeding, management and genetic selection on behavioural, fear and pain problems in dairy cows."

Scientific Opinion - Overall

"Overall assessment of the effects of farming systems on dairy cow welfare and disease"

The present scientific opinion will refer only to metabolic and reproductive problems in dairy cows.

ACKNOWLEDGEMENTS

The European Food Safety Authority and the AHAW Panel wish to thank the members of the Working Group: Donald Broom, Jos Metz, Frans Smulders, Jürgen Rehage, Giuseppe Bertoni, Roel Veerkamp, Pascal Oltenacu, for the development of the Risk Assessment process which has been the basis of this Scientific Opinion.

The scientific co-ordination for this Scientific Opinion has been undertaken by the EFSA AHAW Panel Scientific Officers Denise Candiani and Oriol Ribò.

ASSESSMENT

1. Risk assessment on animal welfare

Animal welfare problems are generally the consequence of negative animal-environment interactions, resulting from animal management factors or housing factors, so called "design criteria" (Anonymous, 2001). The key task of this scientific opinion about the effects of farming systems on the welfare of dairy cows was to find the factors that lead to disease or other causes of poor welfare in dairy cows under current and near future production circumstances. For this purpose a risk assessment was completed.

Presently there are no standards for animal welfare risk assessment. Risk assessment is a systematic, scientifically-based process to estimate the likelihood and severity of a hazard impact and includes four steps: hazard identification; hazard characterisation; exposure assessment; and risk characterisation.

In food risk assessment terminology (Codex Alimentarius, WHO, 1999), a hazard is a biological, chemical or physical agent in, or condition of, food with the potential to cause an adverse health effect. The risk is a function of the probability of an adverse health effect and the severity of that effect, consequential to a hazard(s) in food.

Making a parallel to the Codex Alimentarius risk assessment methodology, a hazard in animal welfare risk assessment is a design criterion (usually an environment-based factor) with a potential to cause a negative animal welfare effect, i.e. an adverse effect as measured by one or more welfare indicators.

A risk in animal welfare is a function of the probability of a negative animal welfare effect and the severity of that effect, consequential to the exposure to a hazard(s).

The degree of confidence in the final estimation of risk depends on the variability, uncertainty, and assumptions identified and integrated in the different risk assessment steps.

Uncertainty analysis describes the fact that we have incomplete knowledge. Uncertainty arises in the evaluation and extrapolation of information obtained from epidemiological, experimental, and laboratory animal studies and whenever attempts are made to extrapolate (i.e. to use data concerning the occurrence of certain phenomena obtained under one set of conditions to make estimations or predictions about phenomena likely to occur under other sets of conditions for which data are not available). Uncertainty could be treated formally in conducting more studies or quasi-formally in using expert opinions or informally by making judgment.

Variability is a biological phenomenon (inherent dispersion) and is not reducible. Reduction in variability is not an improvement in knowledge, but instead would reflect a loss of information.

1.1. Steps of the Risk Assessment

For the following steps of the process, the experts were asked to individually fill in a table (see Table 4) for each population (i.e. dairy cows in cubicles, tie-stalls, straw yards and pasture in Europe), based on the available scientific knowledge and data described in the hazard identification section. Most of the data resulted from expert opinion. The values given by the individual expert were compared and discussed within the working group to reach "consensus scores". A formal elicitation process was used to gather consensual values for the parameters.

1.1.1. Definition of the target populations / farming systems scenarios

The first step in the development of the RA was to identify the target populations to be considered. However, the exposure to a specific hazard can be different according to the different farming systems. The working groups decided to make risk assessments for the following four target populations, corresponding to the most relevant systems presently used for keeping dairy cows (cf. chapter 8 of the scientific report):

- dairy cows kept in cubicle houses;
- dairy cows kept in tie-stalls;
- dairy cows kept in straw yards;
- dairy cows kept at pasture.

The above mentioned systems were defined and considered as follows:

Cubicle house: this is a loose-housing system where cows are kept either for half a year (180 days) or a full year (365 days) in the cubicle house. In some farms they may be able to go outside either always or occasionally to a yard or to pasture for a short or long period.

Tie-stall: cows kept tied up and milked either in their stall or in a milking parlour. In some farms they may be able to go outside either always or occasionally to a yard or to pasture for a short or long period.

Straw yard: this is a loose-housing system with a straw bed as the lying area. A partial concrete floor area behind the feeding fence may be available and the milking system is usually the same as in cubicle houses. Cows are kept in the system either for half a year or a full year. In some farms they may be able to go outside either always or occasionally to a yard or to pasture for a short or long period.

Pasture: cows kept on pasture; the grazing period is considered on half a year basis (180 days). For the other half of the year the cows are kept in one of the other systems. Cows are supposed to be outside full time when on pasture, except for milking. That holds for conditions of health control and calving or feed supplementation.

The way in which these systems are implemented varies among countries in Europe, depending on geographical factors such as climate and soil type, availability of resources, traditions, and market circumstances. In addition, they can also vary substantially among farmers within countries and regions. As it is difficult to consider in the RA all possible systems and situations at EU level, a European average has been considered for the scoring of the RA tables.

1.1.2. Hazard identification

The aim of this step is to identify hazards, i.e. causes or factors that negatively affect the animal's welfare. If animal needs are not met, hazards may occur with consequent adverse effects. In this step, the scientific evidence of association between the exposure to a given production factor (hazard) and the consequent impact on animal welfare are reviewed. Once the target populations were defined, a list of hazards with their adverse effects affecting each of the populations was agreed upon. The hazards were identified in relation to the needs of the animals, as described in Chapter 7 of the Report, in order that no hazards would be omitted. One example is to consider the need to drink, the hazard of difficult access to water and the adverse effects of thirst, dehydration and perhaps anxiety. Another example is the need to rest and exercise, the hazard of slippery floors and the adverse effect of lameness, pain and malaise (Candiani et al., 2007).

For each population, a table was made listing all identified hazards with their adverse effects. If for the same hazard different adverse effects occur, a line for each considered adverse effect was listed.

1.1.3. Hazard Characterisation

The objective of this step is to review and describe the consequences of the exposure to one or several hazards in terms of magnitude and likelihood of the adverse effect for the individual animal. The magnitude of the adverse effect is the product of its severity and duration.

The severity of the adverse effect was scored subjectively by the members of the working group based on the available scientific information about the level of physiological and behavioural responses. Severity scores ranged on a 5 points scale from negligible (score 0) to very severe (score 4). See Table 1 for the severity scores.

Table 1. Severity scores of the adverse effects.

Evaluation	Score	Explanation
Negligible	0	No pain, malaise, frustration, fear or anxiety as evidenced by a range of behavioural, physiological and clinical measures.
Mild	1	Minor changes from normality indicative of pain, malaise, fear or anxiety.
Moderate	2	Moderate changes from normality indicative of pain, malaise, fear or anxiety. Clear change in adrenal or behavioural reactions, such as motor responses and vocalisations.
Severe	3	Substantial changes from normality indicative of pain, malaise, fear or anxiety. Strong change in adrenal or behavioural reactions, such as motor responses and vocalisations.
Very severe	4	Extreme changes from normality indicative of pain, malaise, fear or anxiety, usually in several measures, that could be life-threatening if they persist.

The duration of the effect was expressed as the number of days per year where a cow was believed or expected to be experiencing the adverse effect, once it would be exposed to the hazard. The assessments were always performed on a 1 year basis (365 days).

The magnitude of the adverse effect represents the potential animal welfare adverse effect at the individual level, given that the animal is exposed to the hazard and experiences that adverse effect. For the final estimation of the magnitude of the adverse effect, the severity score was adjusted in order to give even weighting to the scores. Therefore, the magnitude of the adverse effect was calculated as follows:

Magnitude of the adverse effect = (Severity score/4) * Duration of the effect

The experts were also asked to score the quantitative assessment of likelihood that an adverse effect can occur for a given exposure to a hazard. The expert opinion was modelled using a Beta-Pert distribution that requires three parameters, namely minimum, most likely and maximum. The three parameters range from 0 to 100% (see example in Table 4).

The qualitative assessment of Uncertainty for each assessment according with the availability of any scientific evidence was also scored, in agreement with the definition given in Table 2.

Table 2. Qualitative uncertainty scores.

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

1.1.4. Exposure assessment

The assessment of the exposure is the quantitative assessment of the probability of the specific scenario of exposure. The different exposure scenarios were defined by the experts. The scenario takes into account the intensity and duration of an exposure to one or several hazards during the considered period of the animal's life, namely one year, as previously reported (see hazard characterization).

The duration (in days on a 1 year basis) of the exposure to the hazard was agreed by the WG for each target population as follows:

- when the term transition period is used it was considered as 30 days and lactation period was considered as 305 days as it includes the transition period.
- when the hazard was judged to be present only in half a year the duration was calculated as 180 days (for instance in autumn-winter when the cows are housed rather than at pasture).
- when the hazard was judged to be present in half a year plus part of the following season, the duration was considered as 200 days;
- when the hazard was judged to be present only during the two months with more extreme temperatures (i.e. July/August or January/February), the duration was considered to be 60 days;
- other durations were estimated on a case by case basis.

The Intensity of exposure to a hazard is measured either as full exposure/no exposure or exposure to a given range intensity of the hazard (ammonia concentration example). If there are different levels of exposure, one line was created for each level. This is relevant when data on the frequencies of the different level of exposures and data on the relationship between the level of exposure and the severity and likelihood of the consequences (adverse effect) are available.

The likelihood of each exposure scenario (quantitative assessment of likelihood of exposure) for a defined target population was assessed by the experts and then modelled using a Beta-Pert distribution (as before three parameters minimum, most likely and maximum, ranging from 0 to 100% are required). The uncertainty score (see Table 2) for each assessment, was estimated as for the hazard characterization.

The example in Table 3 shows a cow through one year of her life, exposed to an inappropriate water temperature (too low - < 5 °C or too high - > 25 °C) during 2 months per year (60 days), and which, as a consequence of this exposure, suffers from different metabolic and reproductive disorders a respiratory disease of a limited severity during 2 days per year.

Table 3. Example of a consensus. Table for scoring the hazards.

Target population: dairy cows													
Hazard description	**Hazard characterisation**							**Exposure assessment**					
	Adverse effect [b]	**Severity of the adverse effect** [c]	**Duration of the adverse effect (%) d**	**Likelihood of the adverse effect (%)** [e]			**Uncertainty** [f]	**Duration (%)** [g]	**Intensity** [h]	**Likelihood of the exposure to the hazard (%)** [i]			**Uncertainty**[j]
				min	**ml**	**max**				**min**	**ml**	**max**	
Inappropriate temperature of drinking water (too high or too low)	dehydration, reduced feed intake, ketosis, SARA, reproductive failure	1- Limited	2	5	10	15	Medium	60	< 5 C or > 25 C	10	20	30	H

Table 3 Legend:
a = Name of the **Target population**.
b = **Adverse effect** in relation to the needs and consequence of not fulfilling the needs.
c = **Severity** of the adverse effect. Classification based on the criteria in Table 2.
d = **Duration** of the adverse effect given the indicated exposure, during one year.
e = Quantitative assessment of **Likelihood of the adverse effect**: minimum (**min**), most likely (**ml**) and maximum (**max**).
f = **Qualitative Assessment of the Uncertainty**, based on data available for the quantitative assessment (Table 3).
g = **Duration** of the exposure relative to the life time: value from 0% to 100%.
h = **Intensity** of exposure to a hazard, measured either as full exposure/no exposure or exposure to a given range of intensity of the hazard. If there are different levels of exposure, one line was created for each level.
i = Quantitative assessment of **Likelihood of Exposure to the hazard**: minimum (**min**), most likely (**ml**) and maximum (**max**).
j = **Qualitative Assessment of the Uncertainty**, based on data available for the quantitative assessment (Table 3).

1.1.5. Risk Characterisation

Risk characterisation uses hazard characterisation and exposure assessment scores to calculate a risk estimate score expressing the extent of risk of animals in the population exposed to a given hazard.

It aims to give information to the risk manager to evaluate a specific situation regarding the fulfilling of animal needs and maximising good welfare.

Once all the scores were agreed and the consensus tables completed, the risk estimates were calculated for each hazard as follows:

Risk estimate = (Severity score/4) * (Duration of the effect) * (Likelihood of the adverse effect) * (Likelihood of exposure to the hazard)

This formula assumes the following:

that there is linearity on the severity scores (e.g. 2 days suffering from an intensity score 2 is equivalent to 1 day suffering from an intensity score 4).

that there is no interaction between hazards.

that the hazards are mutually exclusive.

Because the previous assumptions are extremely tentative and could not be verified within the scope the WG's mandate, the risk calculation has to be interpreted with extreme caution. A simple interpretation is to consider the risk calculation as the number of days the animals are suffering from poor welfare induced by the exposure to the considered hazard.

To assess the effect of an exposure to several hazards, summation is avoided by precaution, as the different exposures are not mutually exclusive and it is needed to weight the different outcomes before summation.

The risk calculation mainly serves the purpose of ranking the importance of the different considered hazards within the examined populations.

The risk estimate distribution was calculated using a stochastic simulation model. This runs for 20 000 iterations using Monte-Carlo sampling method with @Risk (Palisade, Ithaca, USA) add-in for Microsoft Excel®. The risk output distribution was described using its median, 5th and 95th percentiles.

The qualitative assessment of the uncertainty on the risk output was derived accordingly to a classification matrix (Table 4) used for the calculation of the product of both the uncertainty evaluations, namely the one related to the likelihood and the one related to the exposure.

Table 4. Classification matrix of the qualitative assessment of the uncertainty.

		Exposure uncertainty		
		High	Medium	Low
Adverse effect uncertainty	High	High	High	High
	Medium	High	Medium	Medium
	Low	High	Medium	Low

1.2. Graphical presentation of the Risk Characterisation

The consensus Tables in the Appendix 3 are divided in three sections: Hazard Characterisation (HC), Exposure Assessment (EA) and Risk Characterisation. HC and EA sections include all values agreed by the experts and used to calculate the Risk Characterisation for each hazard listed in the consensus Tables. The Risk estimate (CI 90%) values are reported by the median and the 5th and 95th percentiles (error bars). This distribution takes into account the uncertainty on the measurement used for the estimation.

In the Appendix, for each hazard category within each production system, values of the risk estimate (median, 5th and 95th percentiles) and values of the magnitude of the adverse effect are presented as a histogram. The magnitude of the adverse effect represents the potential animal welfare adverse effect at the individual level, given that the animal is exposed to the hazard and experiences that adverse effect. The risk estimate is an indicator at the population level, considering not only the likelihood of the animals of that population being exposed to a given

hazard, but also the likelihood of the animals to experience an adverse welfare effect if they are exposed.

Both values are given because this will allow risk managers to analyse the RA outcomes according to either the risk that the hazards impose or the magnitude of the adverse effects. A separate graph has been created for each hazard category within each production system and hazards in the graphs have been ordered by decreasing risk estimate value.

1.2.1. Notes to the reader

1) The same hazard may be repeated two or more times, the reason being that hazards may have different adverse effects on animal welfare depending on the duration or intensity of exposure by the animal. Therefore, if for the same hazard different levels of intensity were defined, the hazard was repeated in order to analyze the different intensities separately. Similarly, if for the same hazard different adverse effects can occur, the hazard was repeated and each considered effect was listed.
2) Any difference in the Exposure Assessment between the tables in the different scientific opinions is related to the different hazard specifications.
3) Running numbers in the first column of the Tables cross reference the hazards in the chart.
4) Conclusions including aspects related to more than one specific subject (e.g. behaviour problems but also leg problems) have been incorporated into the scientific opinion on "Leg and locomotion problems in dairy cows" and are not repeated here.
5) The conclusions presented here below have been extrapolated from the outcomes of the risk assessment process and combined with the conclusions obtained from the data presented in the Scientific Report. They are listed in relation to the contents of the Scientific Report. When a conclusion comes from the Risk Assessment it is explicitly stated.
6) The risk assessment outcomes should be interpreted in relation to the level of uncertainty associated with each single risk estimate and to the magnitude of the adverse effects. On the other hand, high uncertainty levels may only concern part of the assessment (hazard characterization or exposure assessment) and do not necessarily imply that the risk estimate is incorrect. High uncertainty is often an indicator of a necessity for research or further data collection.

CONCLUSIONS AND RECOMMENDATIONS

The conclusions presented here below have been extrapolated from the outcomes of the risk assessment process and combined with the conclusions obtained from the data presented in the Scientific Report on the "Effects of farming systems on dairy cow welfare and disease". They are listed in relation to the contents of the Scientific Report. When a conclusion comes from the Risk Assessment it is explicitly stated.

Conclusions including aspects related to more than one specific subject (e.g. udder problems but also leg problems) have been incorporated into the scientific opinion on "Leg and locomotion problems in dairy cows" and are not repeated here.

General conclusions from the risk assessment

- There is a marked variation in the technical conditions of some production systems among EU countries and, as a consequence, on the impact on the welfare of the cows. The variation specifically appears in the exposure assessment, mainly on housing aspects with respect to tie-stalls and straw yards, less for cubicle houses or pasture.
- Nutrition and feeding, management and genetic hazards with the highest probability values to provoke metabolic and reproductive problems in dairy cows welfare are independent of the husbandry systems. These factors however are considered individually in the RA without taking account of possible synergetic effects.
- In cubicles houses the scores for magnitude of the adverse effects are mostly relatively low compared with the scores for risk. For straw yards and tie-stalls, however, the scores for magnitude are on average relatively high.
- Lower risk estimate values in the case of animals kept at pasture may indicate that they are less likely to have metabolic and reproductive problems and therefore poor welfare.

Chapter 3 - Dairy cow farming systems

No conclusions about the differences among farming systems for feeding and nutrition aspects in dairy cows were derived from the scientific report; however, the following conclusions were made as a result of the semi-quantitative **risk assessment**:

- The risk of suffering metabolic and reproductive disorders is independent of the housing system.
- The highest ranked risk hazards in nutrition and feeding, management and genetics were the same in the three indoor husbandry systems considered (cubicles, straw yards and tie-stalls) with similar risk estimate values. The magnitudes of the adverse effects associated with the hazards were also similar.
- In the case of hazards related to housing, poor cubicle design and lack of space were the highest ranked in cubicle houses and tie-stalls, respectively, with high risk estimate values.
- Inadequate ventilation, temperature and humidity were the highest ranked hazard in straw yards. However, the risk estimate and magnitude values in straw yards were much lower than in cubicles and tie-stalls.

- In pasture, risk estimate values were lower than in the indoor systems considered. Magnitudes of the adverse effect were also lower. The impact of genetics was not so much dependent upon the housing system.

Chapter 4 - Genetic change for higher productivity and disease resistance in dairy cattle in relation to welfare

The **risk assessment** showed that:

- No differences according to housing systems have been observed on the effect of the genetic selection on metabolic and reproductive disorders.
- The risk of suffering metabolic and reproductive disorders as a consequence of genetic selection for productivity is higher when the animals are kept without substantial compensatory husbandry (mainly related to feeding).

4.2. Impact of selection and breeding on welfare

4.2.1. Lameness and other production diseases

Conclusions:

- In recent years, breeding programmes have started to take account of and attempt to improve health, fertility and other welfare-related traits.

4.2.3. Fertility problems and decreased longevity

4.2.5. Inbreeding

Conclusions:

- Inbreeding has been estimated to be increasing at 0.17 - 0.2% per year in dairy cows. It may also result in small numbers of sires, perhaps with undesirable characteristics, being widely used. This increase may lead to, or be associated with, increased reproductive problems, reduced lifetime milk production and a reduction in breeding performance if it continues.

Recommendations:

- In order to avoid poor welfare, such as that associated with reproductive disorders and loss of robustness, the breeding procedures for dairy cattle should be designed to reduce inbreeding.

4.3. Selection for high production and consequences for metabolic stress

Conclusions:

- Excessive or prolonged negative energy balance in dairy cows is more likely to occur in the highest producing animals and has been found to be associated with reduced fertility, digestive, metabolic and infectious disease, especially mastitis.

4.4. Selection for improved welfare in dairy cattle

Conclusions:

- Genetic selection for improved fertility, health and longevity is likely to improve welfare and lead to greater profit for the farmer.

Recommendations:

- A multi-trait selection programme in which health, fertility and welfare traits are included in the breeding objective is recommended.

Recommendations for future research:

- Multi-disciplinary research aimed to clarify the relationship between production, negative energy balance, metabolic stress and welfare indicators and to develop practical methods for measuring negative energy balance and metabolic stress is needed. This research should identify traits and selection criteria to provide better selection tools to improve welfare in dairy cows.

Chapter 5 – Nutrition

5.1. Feed and feeding practices

Conclusions:

- Cattle require a diet that is adequate in fibre. If the quantity and quality of dietary fibre are inadequate, the anatomy and physiology of the rumen are impaired and there is increased risk of ruminal acidosis and other related disorders.
- Cows are often in negative energy balance during early lactation. In these circumstances, functional body tissues may be metabolised to excess and this can cause poor welfare. This risk is particularly severe in high-producing genetic strains. Transition period feeding that sustains dry matter intake while maintaining optimal body condition at calving reduces this risk.
- If the components of feed for dairy cattle lack nutrients or are not balanced, or if the feeding system does not allow each animal to obtain sufficient feed, welfare will be poor.
- The **risk assessment** showed that an inadequate transition feeding is the hazard with the highest risk estimates in all indoor farming systems (Note: transition to fresh pasture with low fibre content can also cause problems).
- From the **risk assessment**, no difference among the four farming scenarios has been observed on the impact of an improper ration composition (protein/energy levels at dry period and lactating stages but particularly in the transition period).
- The **risk assessment** showed that in the three indoor systems, for total mixed ration the risk estimate is higher for cows reared in cubicles and tie-stalls compared with straw yards. The possibility to eat some straw is higher in well managed straw yard, but can occur also in tie-stalls.
- The **risk assessment** showed that the risk for improper fibre traits (chemico-physical aspects) is quite high in cubicles and tie-stalls but lower for straw yards. For dairy cows kept on pasture, the magnitude of the adverse effect and the risk estimate are much lower, the reason being a diet mainly based on grazed forages.
- From the **risk assessment**, in the case of component feeding, the magnitude of the effect is similar among the three systems, but the risk estimate is lower in straw yards; otherwise the risk is maximal in the case of tied animals associated with the higher difficulties to properly supply concentrates in many small meals.
- From the **risk assessment**, no difference among the three indoor farming systems has been observed on the impact of an improper way of feeding (frequency of supplying feed or diet composition in relation with stage of lactation and/or dry period).

- The **risk assessment** showed that the impact of the underfeeding is lower, both in terms of magnitude of the effect and risk estimate, in tied animals because the possibility of feeding each cow individually is easier. Overfeeding in late lactation and dry period is the second most important risk for all indoor systems. When dairy cows are kept on pasture, the impact of the underfeeding is lower, both in terms of magnitude of the adverse effect and risk estimate, as well as the impact of overfeeding, since forage is the main feed and excess of energy is more unlikely.
- From the **risk assessment**, no difference among the three indoor farming systems has been observed on the impact of forage quality in terms of palatability and nutritional value.

Recommendations:

- All dairy cattle should be fed a diet that provides sufficient energy, nutrients and dietary fibre to meet the metabolic requirements in a way that is consistent with digestion.
- Feeding systems should allow every individual cow to meet her needs for quantity and quality of feed.

5.2. Water

Conclusions:

- Dairy cows drink 30 to 174 l/day per animal depending on stage of lactation, even when they have much water in their diet, in particular because of their large output of water in milk.
- If there is an inadequate mean of provision of water from which dairy cattle can drink, for example if only nipple drinkers are provided, or if refill rates are inadequate to provide water, the animals may obtain insufficient water with consequent poor welfare indicated by physiological and behavioural disturbances.
- Adverse effects on dairy cattle are caused by poor water quality, for example the presence of: repellent odour and taste, harmful infectious agents, toxic substances and contaminants that can accumulate in body tissue or be excreted in milk.
- Drinking water should be available for animals at all times, should be palatable for them and should be of suitable quality not only when entering the watering system, but also at the time when consumed by animals. Efficient water distribution and delivery systems providing the necessary amounts of water are needed in all dairy cattle keeping systems.
- From the **risk assessment**, no difference has been observed in the impact of water quality on poor welfare among the four farming scenarios.

Recommendations:

- A water supply mechanism which allows a cow to put its mouth down into water should be provided.
- Where water troughs are provided, the number and position should be such that the animals do not need to wait too long or to compete for water.
- Dairy cows should be provided with drinking water whatever their diet. This water should be in sufficient quantity to prevent any dehydration and should be free from repellent odour and taste, harmful infectious agents, toxic substances and contaminants that can accumulate in body tissue or be excreted in milk.

- Both indoors as well as outdoors permanent access to water has to be provided. Automatic regulated troughs and drinker bowels should be installed in the animal houses and farm yards.

5.3. Chemical and microbiological agents and toxic plants

Conclusions:

- Contamination of feed-stuffs with noxious substances or carcasses can harm dairy cattle.
- Where feed-stuffs are preserved, improper drying, ensiling or storage can lead to the presence of toxins or loss of nutritional quality.
- From the **risk assessment**, no difference among farming scenarios has been observed in the impact of forage quality in terms of absence of pathogens or toxic substances.

Recommendations:

- Contamination of feed-stuffs with noxious substances at source or in storage should be avoided.
- Where feed-stuffs are preserved, any drying, ensiling or storage should be properly carried out.

5.4. Metabolic disorders in relation to production pressure

Conclusions:

- Ruminal acidosis (acute and subacute) and parturient paresis (milk fever) can cause very poor welfare in dairy cows. Unbalanced diet is the major cause of sub-acute ruminal acidosis.
- When concentrate dispensers are used, appropriate control is necessary to avoid over/underfeeding and reduce the risk of acute ruminal acidosis. Adequate maintenance of the concentrate feeding facilities on dairy farms is an effective prevention measure for ruminal acidosis.

Recommendations:

- Concentrate feeding facilities on dairy farms should be adequately maintained and diets carefully balanced so as to maintain optimal ruminal fermentation and to minimise negative energy balance.
- Strategies for feeding and management of the dry cow should be designed to prevent metabolic disorders such as parturient paresis (milk fever) which has an acute severe effect on animal welfare.

Chapter 6 - Housing conditions in relation to welfare

6.1. Building design

- In the **risk assessment**, in general, hazards related to housing in pasture have a very low risk probability and if present the magnitude of the adverse effect on the animals is very low.
- Poor cubicle design and lack of space are the highest ranked hazards in cubicle houses and tie-stalls respectively, with similar risk values. The magnitude of the adverse effect is much higher in the case of tie-stalls.

6.5. Ventilation, air quality, climate control, manure gases and light

- Inadequate ventilation is highly ranked in the case of indoor systems but values of risk are very different and much higher in the case of tie-stalls.
- Light level and duration have a very low risk probability and magnitude values when compared with other hazards.

6.7. Bedding

- The **risk assessment** showed that inadequate bedding has been also highly ranked in indoor systems with risk probability values higher in the case of tie-stalls.

6.8.9. Difficulties in comparing access to pasture with different housing systems

Conclusions:

- When dairy cows are kept on pasture there are risks of inclement weather, flies and access to toxic plants.
- When stocking rate is too high and new pasture is not made available at regular intervals, there is an increased risk of parasitism, inadequate energy and fibre intake, inadequate water intake and high competition for feed and water.

Recommendations:

- When possible, dairy cows and heifers should be given access to well managed pasture or other suitable outdoor conditions, at least during summer time or dry weather.

Chapter 11 - Reproduction and welfare

11.1. Reproductive disorders and welfare

Conclusions:

- Reproductive disorders are associated with welfare in two ways: 1) they reflect prolonged or short-term poor welfare, such as lack of oestrus, embryonic loss or early abortion due to stress experienced for longer or shorter time periods around parturition and in early lactation; 2) by causing poor welfare directly, particularly dystocia and genital infections associated with pain or inflammatory reactions.

Recommendations:

- To reduce risk of dystocia particularly at first calving, heifers should be inseminated after they reach the mature weight for the breed and only sires known to have low incidence of dystocia should be used to breed heifers.
- Good hygiene should be provided at calving to reduce risk of genital infections.

11.2. Reproductive strategy and welfare

Conclusions:

- Many farmers intensively manage the reproductive biology of the dairy cows by using hormonal treatments, such as oestrus synchronization and timed insemination, in order to achieve a calving interval of 12 to 13 months which they perceive as economically optimal. This results in poor welfare as it deprives the animals of a coping mechanism

at their disposal, to delay the onset of the reproductive process postpartum, to cope with metabolic stress caused by high production.

- The **risk assessment** showed that inadequate biosecurity is the highest ranked hazard in all husbandry systems. The magnitude of the adverse effect is the same. In the case of pasture the risk estimate value is lower than in the other three systems.
- In the **risk assessment** all hazards related with improper management are highly ranked in all farming systems. However, risk values are very low when compared with inadequate biosecurity and also when compared with housing, nutrition or genetic hazards.

Recommendations for future research:

- Management of modern dairy cows with extended calving intervals should be evaluated with respect to welfare of the cows.

Chapter 12 - Management and disease

Conclusions:

- There is no evidence that deficits in nutrition, housing, handling and management leading to poor fertility in dairy cattle can be compensated by hormonal treatments.

Recommendations:

- Hormonal treatments should not be used to compensate deficits in management.

DOCUMENTS PROVIDED TO EFSA

No documents were provided to EFSA by the European Commission

REFERENCES

Anonymous, 2001. Scientists' Assessment of the Impact of Housing and Management on Animal Welfare. *Journal of Applied Animal Welfare Science* 4:3-52.

Candiani, D., Ribó, O., Barbieri, S., Afonso, A., Grudnik, T. and Serratosa, J., 2007. Risk assessment challenges in the field of animal welfare. In press in the book "The challenge of the farmer: raise food animals in a proper close-environment" - Wageningen Academic Publishers – following Congress of International Society of Animal Hygiene, 2007, Tartu, Estonia.

SCAHAW, 1999. Report on Animal Welfare Aspects of the Use of Bovine Somatotrophin.

WHO, 1999. Codex Alimentarius Commission (CAC). http://www.who.int/foodsafety/publications/micro/cac1999/en/

APPENDICES

APPENDIX A

RISK ASSESSMENT TABLES AND FIGURES

The following appendix reports the risk assessment tables that were compiled and scored by the Working Group. The subsequent graphs, where hazards are ranked by their risk estimate values, correspond to the outcomes of the risk assessment.

CUBICLE HOUSES MET & REPR																			
Chapter of the scient. report	Hazard identification			Hazard characterization							Exposure assessment						Risk Characterization		
	Hazard Nr.	Hazard description	Hazard specification	Adverse effect	Severity of the adverse effect	Duration of the adverse effect	Likelihood of the adverse effect			Uncertainty	Duration of the hazard	Intensity	Likelihood of the exposure to the hazard			Uncertainty	Risk estimate	Magnitude of adverse effect	Qualtitative uncertainty
							min	ml	max				min	ml	max				
		HOUSING																	
6.5.	**1**	**Inadequate ventilation, inappropriate airflow, airspeed**	too low ventilation (1/3 of winter period)	reduced feed intake, immunosuppression, less oestrus expression, reduced fertility, SARA, ketosis.	2	30	40	60	80	M	60	<60 m3 air/500 kg LW/h	5	10	15	M	0.9	15	M
6.5.	**2**	**Inadequate ventilation, inappropriate airflow, airspeed**	too low ventilation (1/3 of indoor period + part of summer)	reduced feed intake, immunosuppression, less oestrus expression, reduced fertility, SARA, ketosis.	3	80	40	60	80	L	120	<60 m3 (300 in summer) air/500 kg LW/h	5	10	15	M	3.6	60	M
6.5.	**3**	**Insufficient light level (day/night)**	too dark (for both cows and stockperson)	reduced disease detection, reduced fertility, sub-optimal feed intake	1	20	0	5	10	H	45	< 40 lux	5	10	15	M	0.025	5	H
6.5.	**4**	**light duration**	too short	reduced fertility, sub-optimal feed intake	1	25	0	2	4	M	60	< 14 h	15	30	50	M	0.0375	6.25	M
5.1 / 6.1	**5**	**inadequate feeding installation**	automatic feeder failure	reduced or excessive feed intake, acute ruminal acidosis	4	7	30	50	70	L	1	full exposure	0.1	0.2	0.3	M	0.007	7	M
6.1	**6**	**Poor stall (cubicle) design**	--	SARA, ketosis, reduced fertility	2	60	40	50	60	L	365	full exposure	40	70	90	L	10.5	30	L

Figure 1. Risk assessment: hazards related to housing in dairy cows kept in cubicle houses.

CUBICLE HOUSES MET & REPR																				
Chapter of the scient. report	Hazard identification			Hazard characterization							Exposure assessment						Risk Characterization		
	Hazard Nr.	Hazard description	Hazard specification	Adverse effect	Severity of the adverse effect	Duration of the adverse effect	Likelihood of the adverse effect			Uncertainty	Duration of the hazard	Intensity	Likelihood of the exposure to the hazard			Uncertainty	Risk estimate	Magnitude of adverse effect	Qualtitative uncertainty
							min	ml	max				min	ml	max				
		HOUSING																	
6.7	7	**Inadequate bedding**	hygiene, composition and quantity (in zero-grazing)	SARA, ketosis, reduced fertility, pain	2	60	30	40	50	L	365	full exposure	30	50	70	M	6	30	M
6.7	8	**Inadequate bedding**	hygiene, composition and quantity (with access to pasture)	SARA, ketosis, reduced fertility, pain	2	20	30	40	50	L	180	full exposure	30	50	70	M	2	10	M
6.1	9	**Inadequate floor in area where cows walk**	too slippery, too hard, injuring, too rough	ketosis, reduced fertility	1	30	30	50	70	M	365	full exposure	50	70	100	M	2.625	7.5	M
6.2	10	**Lack of space, e.g. for exercising, social interactions and resting**	--	immunosuppression, less oestrus expression, reduced fertility, ketosis	2	60	5	10	15	M	365	full exposure	40	60	80	H	1.8	30	H
12.3	11	**Lack of facilities for sick animals**	--	downer cow, (check calving problems in the rest of this table)	3	7	0.5	1	1.5	L	365	full exposure	50	70	90	H	0.03675	5.25	H

Figure 1. Risk assessment: hazards related to housing in dairy cows kept in cubicle houses (continued).

CUBICLE HOUSES MET & REPR																			
	Hazard identification			Hazard characterization							Exposure assessment						Risk Characterization		
Chapter of the scient. report	Hazard Nr.	Hazard description	Hazard specification	Adverse effect	Severity of the adverse effect	Duration of the adverse effect	Likelihood of the adverse effect			Uncertainty	Duration of the hazard	Intensity	Likelihood of the exposure to the hazard			Uncertainty	Risk estimate	Magnitude of adverse effect	Qualtitative uncertainty
							min	ml	max				min	ml	max				
		HOUSING																	
6.2	12	**Fewer cubicles than cows**	with access to pasture	SARA, ketosis, reduced fertility	2	60	3	5	7	L	180	full exposure	1	2	3	H	0.03	30	H
6.2	13	**Fewer cubicles than cows**	zero-grazing	SARA, ketosis, reduced fertility	2	365	3	5	7	L	365	>10% overstocking	1	2	3	H	0.1825	182.5	H
5.2	14	**Insufficient access to water**	inappropriate system design	reduced dry matter intake, SARA, ketosis	1	120	30	50	70	M	365	any cow can't access water for 5 hours	1	5	10	H	0.75	30	H
5.2	15	**Insufficient access to water**	broken system, management problem, etc…	dehydration, reduced dry matter intake, SARA	2	1	70	80	90	L	1	total lack of water	0	0.1	0.2	H	0.0004	0.5	H
13.1	16	**Inadequate or lack of handling/restraining facilities**	--	reproductive failure, injuries	3	10	0.01	0.1	0.2	H	10	full exposure	30	50	70	H	0.00375	7.5	H
6.5	17	**Inappropriate temperature, humidity**	--	reduced feed intake, ketosis, SARA, reproductive failure	1	20	15	30	45	M	30	75<THI<78	50	60	70	M	0.9	5	M

Figure 1. Risk assessment: hazards related to housing in dairy cows kept in cubicle houses (continued).

CUBICLE HOUSES MET & REPR																			
	Hazard identification			Hazard characterization							Exposure assessment						Risk Characterization		
Chapter of the scient. report	Hazard Nr.	Hazard description	Hazard specification	Adverse effect	Severity of the adverse effect	Duration of the adverse effect	Likelihood of the adverse effect			Uncertainty	Duration of the hazard	Intensity	Likelihood of the exposure to the hazard			Uncertainty	Risk estimate	Magnitude of adverse effect	Qualtitative uncertainty
							min	ml	max				min	ml	max				
		HOUSING																	
6.5	18	**Inappropriate temperature, humidity**	--	dehydration, reduced feed intake, ketosis, SARA, reproductive failure	2	12	40	50	60	M	15	78<THI<83	40	50	60	M	1.5	6	M
6.5	19	**Inappropriate temperature, humidity**	--	dehydration, reduced feed intake, ketosis, SARA, reproductive failure	3	5	60	80	100	M	5	THI>83	10	15	20	M	0.45	3.75	M
8.2	20	**Poor calving conditions**	absence of pen, pen design, facilities (inability to separate from other animals)	uterus infection, dystocia, reduced fertility, prolonged parturition, reduced feed intake, fatty liver, downer cows	2	21	20	30	40	L	7	full exposure	30	50	70	H	1.575	10.5	H
6.1	21	**too few feeding places in zero grazing systems**	--	reduced feed intake, ketosis, SARA, reproductive failure	2	60	5	10	15	L	365	> 1 cow per place	5	10	15	H	0.3	30	H
6.1	22	**too few feeding places (cows with access to pasture)**	--	reduced feed intake, ketosis, SARA, reproductive failure	2	60	5	10	15	L	215	> 1 cow per place	10	20	30	H	0.6	30	H

Figure 1. Risk assessment: hazards related to housing in dairy cows kept in cubicle houses (continued).

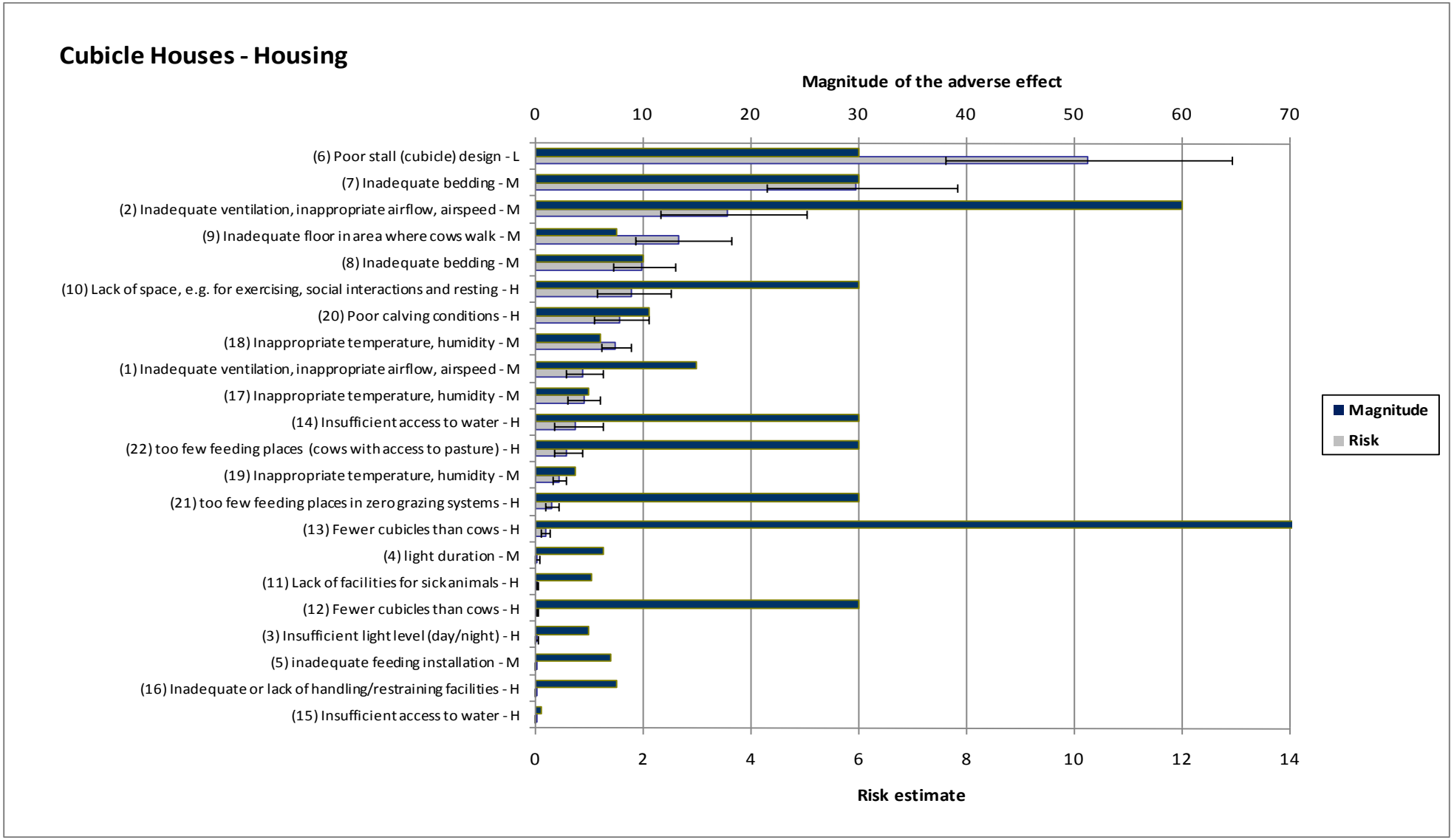

Figure 2. Ranking of hazards related to housing in dairy cows kept in cubicle houses.

CUBICLE HOUSES MET & REPR																				
	Hazard identification			Hazard characterization							Exposure assessment						Risk Characterization		
Chapter of the scient. report	Hazard Nr.	Hazard description	Hazard specification	Adverse effect	Severity of the adverse effect	Duration of the adverse effect	Likelihood of the adverse effect			Uncertainty	Duration of the hazard	Intensity	Likelihood of the exposure to the hazard			Uncertainty	Risk estimate	Magnitude of adverse effect	Qualtitative uncertainty
							min	ml	max				min	ml	max				
NUTRITION AND FEEDING																			
5.2	1	**Water quality: inappropriate water temperature**	too high or too low	dehydration, reduced feed intake, ketosis, SARA, reproductive failure	1	2	5	10	15	M	60	< 5 C or > 25 C	10	20	30	H	0.01	0.5	H
5.2	2	**Improper sensory quality of the water source**	salt, iron, pollutants	dehydration, reduced feed intake, ketosis, reproductive failure	1	5	3	5	7	M	365	> 3000 ppm total dissolved solids	1	5	10	H	0.00313	1.25	H
5.1	3	**Poor feed quality (roughage)**	Poor nutritive value, Improper sensory quality of feed	reduced feed intake, ketosis, reproductive failure	2	60	30	40	50	L	100	Ammonia, butiric acid levels	5	10	15	H	1.2	30	H
5.1	4	**Poor feed quality (roughage)**	prevalence of pathogen and toxic substances affecting cattle	ketosis, reproductive failure	1	15	5	10	15	M	100	i.e. presence of Listeria, butolinus toxine, mycotoxines	15	25	35	H	0.09375	3.75	H
5.1	5	**Improper ration composition**	inadequate protein/carbohydrate ratio	ketosis, reproductive failure	1	15	10	15	20	L	325	urea in milk <150 ppm or >350 ppm	15	25	35	H	0.14063	3.75	H
5.1	6	**Improper ration composition (TMR)**	Inadequate fibre/carbohydrate ratio and fibre quality/length	SARA, reproductive failure	2	100	60	70	80	L	325	rumen pH < 5.8 more than 3 hours	10	15	20	M	5.25	50	M

Figure 3. Risk assessment: hazards related to nutrition and feeding in dairy cows kept in cubicle houses.

CUBICLE HOUSES MET & REPR																				
	Hazard identification			Hazard characterization							Exposure assessment						Risk Characterization		
Chapter of the scient. report	Hazard Nr.	Hazard description	Hazard specification	Adverse effect	Severity of the adverse effect	Duration of the adverse effect	Likelihood of the adverse effect			Uncertainty	Duration of the hazard	Intensity	Likelihood of the exposure to the hazard			Uncertainty	Risk estimate	Magnitude of adverse effect	Qualtitative uncertainty
							min	ml	max				min	ml	max				
NUTRITION AND FEEDING																			
5.1	7	**Improper ration composition (CF)**	Inadequate fibre/carbohydrate ratio and fibre quality/length	SARA, reproductive failure	2	40	60	70	80	L	120	rumen pH < 5.8 more than 3 hours	15	20	25	H	2.8	20	H
5.1	8	**Underfeeding**	including inadequate nutrient supply in relation to genotype and energy output	ketosis, exhaustion, decreased fertility, immunosuppresssion	3	40	60	70	80	L	80	> BHB 1.2 mmol/l or loss in BCS >1	10	25	40	M	5.25	30	M
5.1	9	**Inadequate transition feeding**	Inadequate feeding strategy, energy and fibre supply	ketosis, decreased fertility, SARA, immunosuppresssion	2	70	50	60	70	L	45	See S. Report Chapter 10	30	50	70	M	10.5	35	M
5.1	10	**Overfeeding**	excess of nutrient supply in relation to genotype and energy output at the end of lactation and dry period	ketosis, dystocia, milk fever, downer cow, displaced abomasum, decreased fertility	3	70	30	50	70	L	100	BCS > 3.75 at calving	15	20	25	M	5.25	52.5	M
5.1	11	**Inadequate feeding schedule (poor bunk management)**	frequency and regularity of supplying feed	SARA, ketosis, reduced fertility	1	60	10	20	30	M	325	period of absence of feed >1 h	5	10	15	H	0.3	15	H

Figure 3. Risk assessment: hazards related to nutrition and feeding in dairy cows kept in cubicle houses (continued).

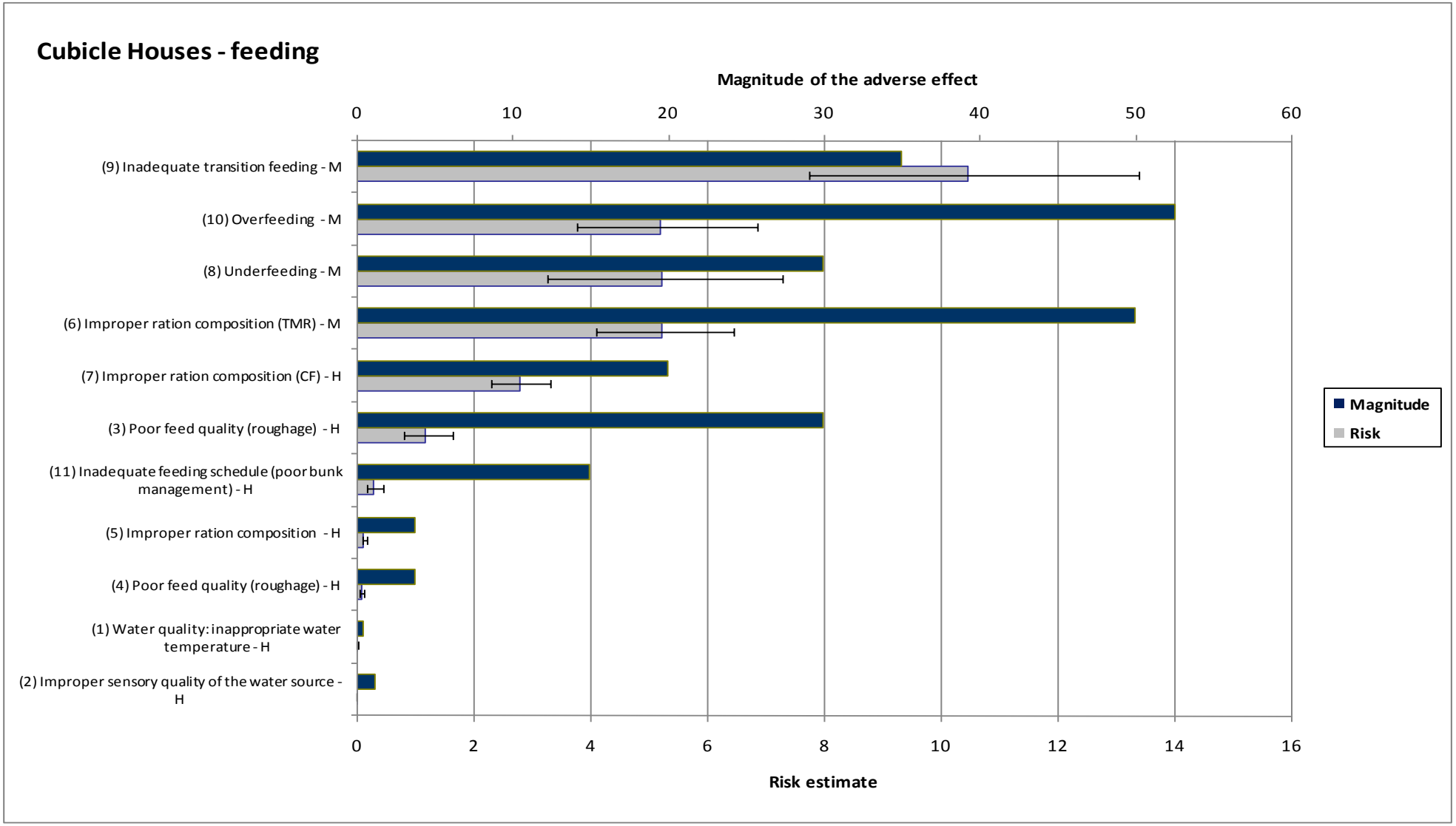

Figure 4. Ranking of hazards related to nutrition and feeding in dairy cows kept in cubicle houses.

CUBICLE HOUSES MET & REPR																				
	Hazard identification			Hazard characterization							Exposure assessment						Risk Characterization		
Chapter of the scient. report	Hazard Nr.	Hazard description	Hazard specification	Adverse effect	Severity of the adverse effect	Duration of the adverse effect	Likelihood of the adverse effect			Uncertainty	Duration of the hazard	Intensity	Likelihood of the exposure to the hazard			Uncertainty	Risk estimate	Magnitude of adverse effect	Qualtitative uncertainty
							min	ml	max				min	ml	max				
MANAGEMENT																			
8.2. / 8.3 / 8.4	**1**	**Poor calving management**		uterus infection, dystocia, reduced fertility, prolonged parturition, reduced feed intake, fatty liver, downer cows	3	15	5	10	15	L	5	full exposure	50	60	70	H	0.675	11.25	H
8.1	**2**	**Mixing animals from different groups**	the single animal is moved to another group	reduced feed intake, ketosis, reproductive failure	2	5	30	40	50	L	5	full exposure	98	99	100	M	0.99	2.5	M
8.1	**3**	**Mixing animals from different groups (big farms: > 100 cows)**	the group receiving new animals	reduced feed intake, ketosis, reproductive failure	1	10	3	5	7	M	190	full exposure	60	70	80	M	0.0875	2.5	M
8.1	**4**	**Mixing animals from different groups (small farms < 100 cows)**	the group receiving new animals	reduced feed intake, ketosis, reproductive failure	1	7	6	10	14	M	30	full exposure	20	30	40	M	0.0525	1.75	M
13.1	**5**	**Insufficient or inappropriate contact with humans**	maltreatment;animals maintain fear to stckperson	reduced feed intake, ketosis, reproductive failure	2	1	20	50	80	H	365	high % of negative contact	15	25	35	H	0.0625	0.5	H

Figure 5. Risk assessment: hazards related to management in dairy cows kept in cubicle houses.

CUBICLE HOUSES MET & REPR																				
	Hazard identification			Hazard characterization							Exposure assessment						Risk Characterization		
Chapter of the scient. report	Hazard Nr.	Hazard description	Hazard specification	Adverse effect	Severity of the adverse effect	Duration of the adverse effect	Likelihood of the adverse effect			Uncertainty	Duration of the hazard	Intensity	Likelihood of the exposure to the hazard			Uncertainty	Risk estimate	Magnitude of adverse effect	Qualtitative uncertainty
							min	ml	max				min	ml	max				
MANAGEMENT																			
13.1	**6**	**Insufficient or inappropriate contact with humans**	low acceptance of treatment by stockperson	reproductive failure	1	1	5	10	15	H	365	few or no positive contact	20	30	40	H	0.0075	0.25	H
14	**7**	**Insufficient or inappropriate care of animals by stockperson**	neglect, lack of knowledge or lack of time	prolonged metabolic disease, delayed treatment of disease, dystocia, reproductive failure	2	7	60	70	80	M	365	full exposure	20	30	40	H	0.735	3.5	H
12.3 /11.2	**8**	**Inadequate preventive medicine, herd-health management including health recording**	neglect, lack of knowledge or lack of time	prolonged metabolic disease, delayed treatment of disease, dystocia, reproductive failure	2	10	20	30	40	M	365	full exposure	30	45	60	H	0.675	5	H
12.3	**9**	**Inappropriate hormonal interventions on groups of animals**	mismatch physiological condition with the treatment	risk of improper treatment, induced abortion, metabolic stress	2	15	50	60	70	H	80	full exposure	2	5	8	H	0.225	7.5	H

Figure 5. Risk assessment: hazards related to management in dairy cows kept in cubicle houses (continued).

CUBICLE HOUSES MET & REPR																				
	Hazard identification			Hazard characterization							Exposure assessment						Risk Characterization		
Chapter of the scient. report	Hazard Nr.	Hazard description	Hazard specification	Adverse effect	Severity of the adverse effect	Duration of the adverse effect	Likelihood of the adverse effect			Uncertainty	Duration of the hazard	Intensity	Likelihood of the exposure to the hazard			Uncertainty	Risk estimate	Magnitude of adverse effect	Qualtitative uncertainty
							min	ml	max				min	ml	max				
MANAGEMENT																			
12.3	**10**	**Inadequate biosecurity**	inadequate cleaning (and disinfection) on the farm e.g. floor, cubicles, quarantine pen, calving pen, milking machine	uterus infection, reproductive failure, abortion	2	30	15	20	25	H	365	full exposure	40	60	80	H	1.8	15	H
12.3	**11**	**Inadequate biosecurity**	introducing infectious/diseased cattle (without quarantine and testing) e.g. BVD, Johnes Disease, Leptospira	uterus infection, reproductive failure, abortion, metabolic stress due to disease	3	30	40	60	80	H	5	full exposure	50	70	90	H	9.45	22.5	H
12.3	**12**	**Inadequate biosecurity**	inadequate control of pest and vectors	uterus infection, reproductive failure, abortion, metabolic stress due to disease	3	30	5	10	15	H	100	full exposure	10	20	30	H	0.45	22.5	H
12.3 /11.2	**13**	**Witholding veterinary therapeutic care with clinical disease**		including unnecessarily metabolic and reproductive disease, uterus disease, including unnecessarily prolonged disease, early culling	2	15	30	40	50	H	40	full exposure	20	30	40	H	0.9	7.5	H

Figure 5. Risk assessment: hazards related to management in dairy cows kept in cubicle houses (continued).

CUBICLE HOUSES MET & REPR																			
	Hazard identification			Hazard characterization							Exposure assessment						Risk Characterization		
Chapter of the scient. report	Hazard Nr.	Hazard description	Hazard specification	Adverse effect	Severity of the adverse effect	Duration of the adverse effect	Likelihood of the adverse effect			Uncertainty	Duration of the hazard	Intensity	Likelihood of the exposure to the hazard			Uncertainty	Risk estimate	Magnitude of adverse effect	Qualtitative uncertainty
							min	ml	max				min	ml	max				
MANAGEMENT																			
12.3 /11.2	**14**	**Improper operational pain management**	Any surgery (e.g. caesarean, displaced abomasum, obstetric interventions, including foetotomy)	reduced DMI, metabolic disease, reduced fertility	3	5	60	70	80	M	10	full exposure	50	60	70	M	1.575	3.75	M
13.5	**15**	**Improper obstetric interventions**	pregnancy diagnostic, treatment of metritis, retained placenta, improper use of calf pullers, etc..	uterus infection, metabolic diseases, reduced fertility, culling, death	3	10	60	70	80	M	21	full exposure	10	20	30	M	1.05	7.5	M
13.5	**16**	**Difficult calving because of the sire**	Dystocia	uterus infection, reduced DMI, metabolic disease, perinatal mortality, culling	2	14	60	70	80	M	1	full exposure	5	10	15	L	0.49	7	M
13.7	**17**	**Downer cow**	Improper management of downer cows - Lack of: physiotherapy, good bedding, proper facilities and lifting devices	metabolic diseases, culling, death	4	5	98	99	100	L	15	full exposure	0.5	1	1.5	M	0.0495	5	M

Figure 5. Risk assessment: hazards related to management in dairy cows kept in cubicle houses (continued).

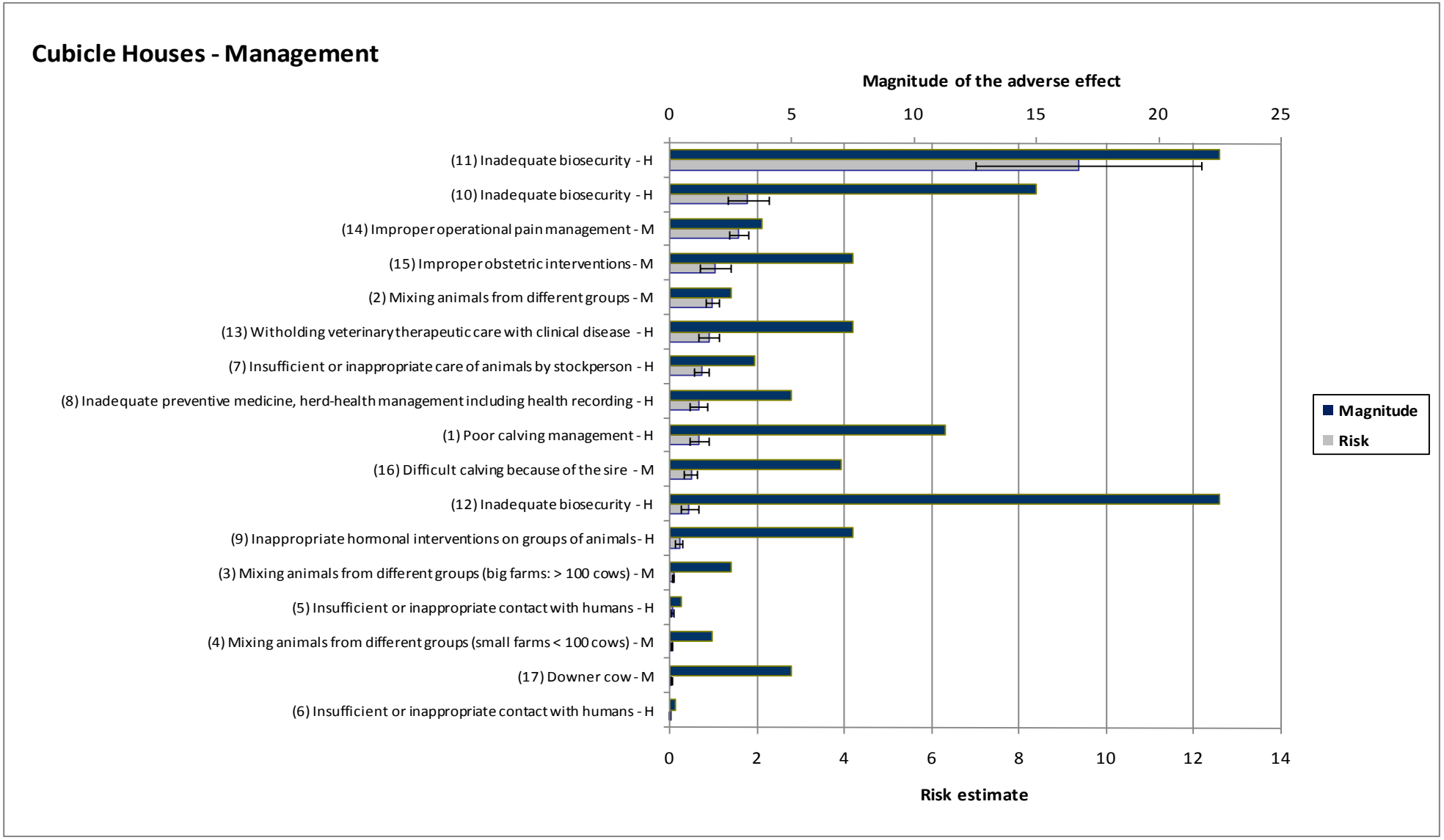

Figure 6. Ranking of hazards related to management in dairy cows kept in cubicle houses

CUBICLE HOUSES MET & REPR																				
	Hazard identification			Hazard characterization							Exposure assessment						Risk Characterization		
Chapter of the scient. report	Hazard Nr.	Hazard description	Hazard specification	Adverse effect	Severity of the adverse effect	Duration of the adverse effect	Likelihood of the adverse effect			Uncertainty	Duration of the hazard	Intensity	Likelihood of the exposure to the hazard			Uncertainty	Risk estimate	Magnitude of adverse effect	Qualtitative uncertainty
							min	ml	max				min	ml	max				
GENETICS																			
4.2	1	**high genetic potential for production due to selection ignoring other traits**	with good housing, nutrition and management	reproductive disorders	2	40	20	30	40	L	365	estimated breeding value for yield in top quartile for breed and country	20	30	40	H	1.8	20	H
4.2	2	**high genetic potential for production due to selection ignoring other traits**	without good housing, nutrition and management	reproductive disorders	3	60	30	40	50	M	365	estimated breeding value for yield in top quartile for breed and country	30	40	50	H	7.2	45	H
4.2	3	**high genetic potential for production due to selection ignoring other traits**	with good housing, nutrition and management	metabolic disorders	2	60	20	30	40	L	365	estimated breeding value for yield in top quartile for breed and country	20	30	40	H	2.7	30	H
4.2	4	**high genetic potential for production due to selection ignoring other traits**	without good housing, nutrition and management	metabolic disorders	3	80	30	40	50	M	365	estimated breeding value for yield in top quartile for breed and country	30	40	50	H	9.6	60	H

Figure 7. Risk assessment hazards related to genetics in dairy cows kept in cubicle houses.

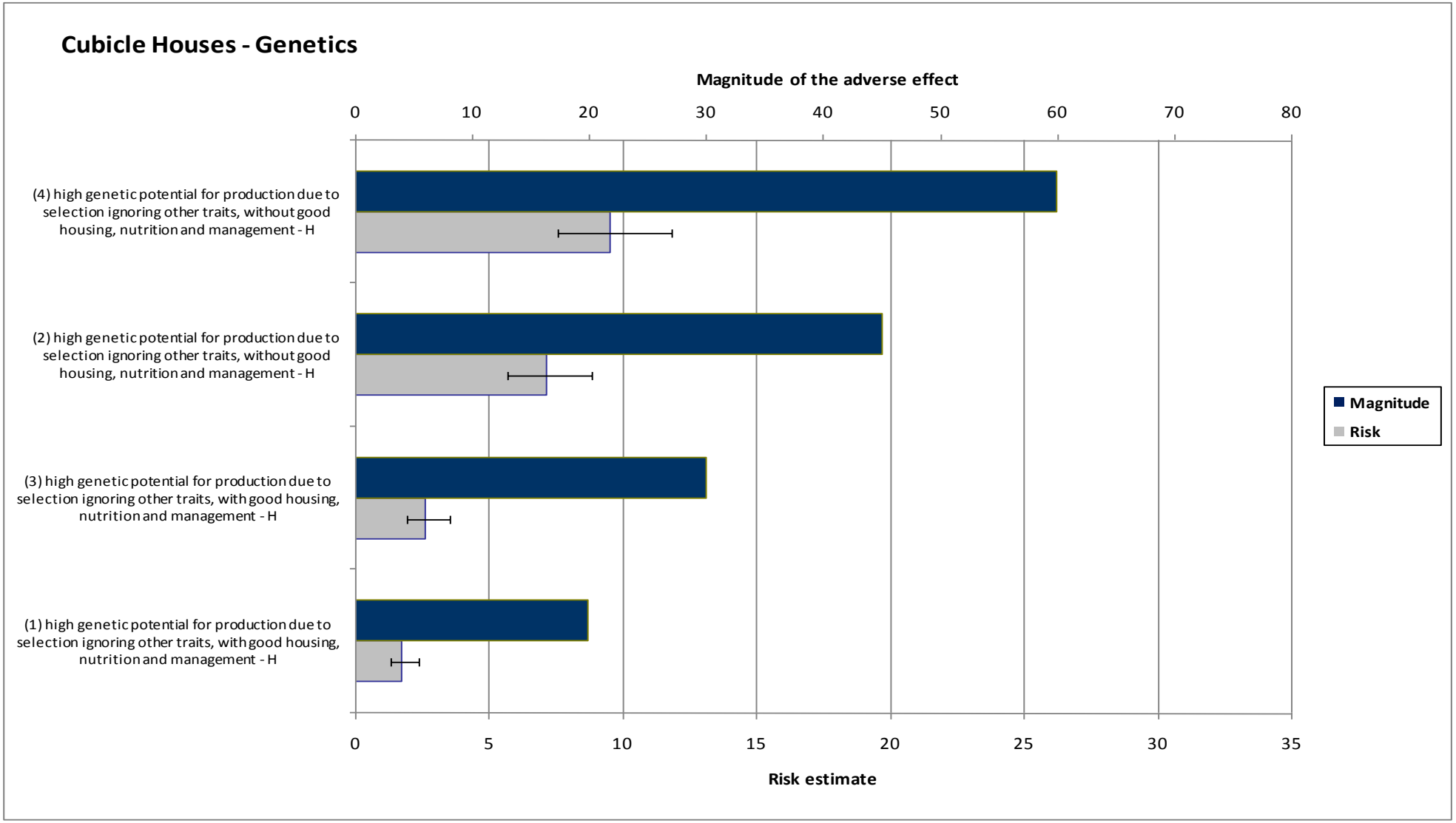

Figure 8. Ranking of hazards related to genetics in dairy cows kept in cubicle houses.

TIE -STALLS				MET & REPR																
Chapter of the scient. report	Hazard identification			Hazard characterization							Exposure assessment						Risk Characterization		
	Hazard Nr.	Hazard description	Hazard specification	Adverse effect	Severity of the adverse effect	Duration of the adverse effect	Likelihood of the adverse effect			Uncertainty	Duration of the hazard	Intensity	Likelihood of the exposure to the hazard			Uncertainty	Risk estimate	Magnitude of adverse effect	Qualtitative uncertainty
							min	ml	max				min	ml	max				
HOUSING																			
6.5.	1	**Inadequate ventilation, inappropriate airflow, airspeed**	too low ventilation (1/3 of winter period)	reduced feed intake, immunosuppression, less oestrus expression, reduced fertility, SARA, ketosis.	2	30	40	60	80	M	60	<60 m3 air/500 kg LW/h	15	20	30	M	1.80	15	M
6.5.	2	**Inadequate ventilation, inappropriate airflow, airspeed**	too low ventilation (1/3 of indoor period + part of summer)	reduced feed intake, immunosuppression, less oestrus expression, reduced fertility, SARA, ketosis.	3	80	40	60	80	L	120	<60 m3 (300 in summer) air/500 kg LW/h	15	20	30	M	7.20	60	M
6.5.	3	**Insufficient light level (day/night)**	too dark (for both cows and stockperson)	reduced disease detection, reduced fertility, sub-optimal feed intake	1	20	0	5	10	H	45	< 40 lux	5	10	15	M	0.03	5	H
6.5.	4	**light duration**	too short	reduced fertility, sub-optimal feed intake	1	25	0	2	4	M	60	< 14 h	15	30	50	M	0.04	6.25	M
5.1 / 6.1	5	**inadequate feeding installation**	automatic feeder failure	reduced or excessive feed intake, acute ruminal acidosis	2	4	15	25	40	L	1	full exposure	0.1	0.2	0.3	M	0.00	2	M
6.1	6	**Poor stall (cubicle) design**	--	SARA, ketosis, reduced fertility	2	60	30	40	50	L	365	full exposure	25	35	45	M	4.20	30	M
6.7	7	**Inadequate bedding**	hygiene, composition and quantity (in zero-grazing)	SARA, ketosis, reduced fertility, pain	2	60	30	35	40	L	365	full exposure	30	40	50	M	4.20	30	M
6.7	8	**Inadequate bedding**	hygiene, composition and quantity (with access to pasture)	SARA, ketosis, reduced fertility, pain	2	20	30	35	40	L	180	full exposure	30	40	50	M	1.40	10	M
6.1	9	**Inadequate floor (limited to passage ways, feeding and milking areas)**	too slippery, too hard, injuring, too rough	ketosis, reduced fertility	1	30	10	20	30	M	365	full exposure	30	50	70	M	0.75	7.5	M

Figure 9. Risk assessment hazards related to housing in dairy cows kept in tie-stalls.

TIE -STALLS				MET & REPR																
Chapter of the scient. report	Hazard identification			Hazard characterization							Exposure assessment						Risk Characterization		
	Hazard Nr.	Hazard description	Hazard specification	Adverse effect	Severity of the adverse effect	Duration of the adverse effect	Likelihood of the adverse effect			Uncertainty	Duration of the hazard	Intensity	Likelihood of the exposure to the hazard			Uncertainty	Risk estimate	Magnitude of adverse effect	Qualtitative uncertainty
							min	ml	max				min	ml	max				
HOUSING																			
6.2	10	**Lack of space, e.g. for exercising, social interactions and resting**	--	immunosuppression, less oestrus expression, reduced fertility, ketosis	3	60	20	30	40	M	365	full exposure	40	60	80	H	8.10	45	H
12.3	11	**Lack of facilities for sick animals**	--	downer cow, (check calving problems in the rest of this table)	3	7	0.5	1	1.5	L	365	full exposure	50	70	90	H	0.04	5.25	H
5.2	12	**Insufficient access to water**	inappropriate system design	reduced dry matter intake, SARA, ketosis	1	120	30	40	50	M	365	any cow can't access water for 5 hours	1	3	5	H	0.36	30	H
5.2	13	**Insufficient access to water**	broken system, management problem, etc…	dehydration, reduced dry matter intake, SARA	2	1	70	80	90	L	1	total lack of water	0	0.1	0.2	H	0.00	0.5	H
13.1	14	**Inadequate or lack of handling/restraining facilities**		reproductive failure, injuries	3	10	0.01	0.1	0.2	H	10	full exposure	15	20	25	H	0.00	7.5	H
6.5	15	**Inappropriate temperature, humidity**		reduced feed intake, ketosis, SARA, reproductive failure	1	20	15	30	45	M	30	75<THI<78	60	70	80	H	1.05	5	H
6.5	16	**Inappropriate temperature, humidity**		dehydration, reduced feed intake, ketosis, SARA, reproductive failure	2	12	40	50	60	M	15	78<THI<83	50	60	70	H	1.80	6	H
6.5	17	**Inappropriate temperature, humidity**		dehydration, reduced feed intake, ketosis, SARA, reproductive failure	3	5	60	80	100	M	5	THI>83	15	25	35	H	0.75	3.75	H
8.2	18	**Poor calving conditions**	absence of pen, pen design, facilities (inability to separate from other animals)	metritis, dystocia, reduced fertility, prolonged parturition, reduced feed intake, fatty liver, downer cows	2	21	10	20	30	L	7	full exposure	60	75	90	M	1.58	10.5	M

Figure 9. Risk assessment hazards related to housing in dairy cows kept in tie-stalls (continued).

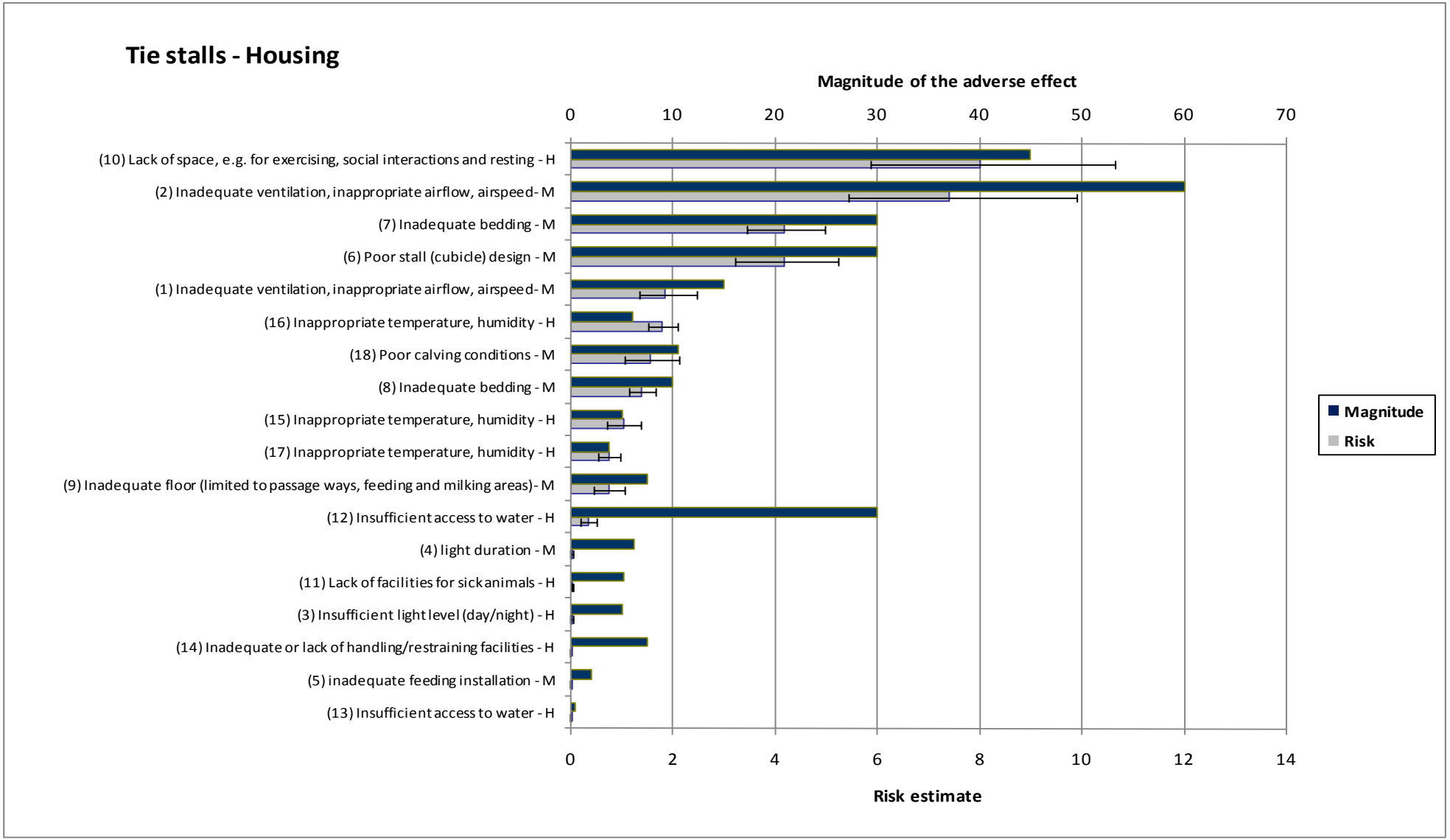

Figure 20. Ranking of hazards related to housing in dairy cows kept in tie-stalls.

TIE -STALLS				MET & REPR															
	Hazard identification			Hazard characterization							Exposure assessment						Risk Characterization		
Chapter of the scient. report	Hazard Nr.	Hazard description	Hazard specification	Adverse effect	Severity of the adverse effect	Duration of the adverse effect	Likelihood of the adverse effect			Uncertainty	Duration of the hazard	Intensity	Likelihood of the exposure to the hazard			Uncertainty	Risk estimate	Magnitude of adverse effect	Qualtitative uncertainty
							min	ml	max				min	ml	max				
NUTRITION AND FEEDING																			
5.2	1	**Water quality: inappropriate water temperature**	too high or too low	dehydration, reduced feed intake, ketosis, SARA, reproductive failure	1	2	5	10	15	M	60	< 5 C or > 25 C	10	20	30	H	0.01	0.5	H
5.2	2	**Improper sensory quality of the water source**	salt, iron, pollutants	dehydration, reduced feed intake, ketosis, reproductive failure	1	5	3	5	7	M	365	> 3000 ppm total dissolved solids	1	5	10	H	0.00	1.25	H
5.1	3	**Poor feed quality (roughage)**	Poor nutritive value, Improper sensory quality of feed	reduced feed intake, ketosis, reproductive failure	2	60	30	40	50	L	100	Ammonia, butiric acid levels	5	10	15	H	1.20	30	H
5.1	4	**Poor feed quality (roughage)**	prevalence of pathogen and toxic substances affecting cattle	ketosis, reproductive failure	1	15	5	10	15	M	100	i.e. presence of Listeria, butolinus toxine, mycotoxines	15	25	35	H	0.09	3.75	H
5.1	5	**Improper ration composition**	inadequate protein/carbohydrate ratio	ketosis, reproductive failure	1	15	10	15	20	L	325	urea in milk <150 ppm or >350 ppm	15	25	35	H	0.14	3.75	H
10.1	6	**Improper ration composition (TMR)**	Inadequate fibre/carbohydrate ratio and fibre quality/length	SARA, reproductive failure	2	100	60	70	80	L	325	rumen pH < 5.8 more than 3 hours	5	10	15	H	3.50	50	H

Figure 31. Risk assessment hazards related to nutrition and feeding in dairy cows kept in tie-stalls.

TIE -STALLS				MET & REPR																
Chapter of the scient. report	Hazard identification			Hazard characterization							Exposure assessment						Risk Characterization		
	Hazard Nr.	Hazard description	Hazard specification	Adverse effect	Severity of the adverse effect	Duration of the adverse effect	Likelihood of the adverse effect			Uncertainty	Duration of the hazard	Intensity	Likelihood of the exposure to the hazard			Uncertainty	Risk estimate	Magnitude of adverse effect	Qualtitative uncertainty
							min	ml	max				min	ml	max				
NUTRITION AND FEEDING																			
10.1	7	**Improper ration composition (CF)**	Inadequate fibre/carbohydrate ratio and fibre quality/length	SARA, reproductive failure	2	40	60	70	80	L	120	rumen pH < 5.8 more than 3 hours	30	35	40	H	4.90	20	H
5.1	8	**Underfeeding**	including inadequate nutrient supply in relation to genotype and energy output	ketosis, exhaustion, decreased fertility, immunosuppresssion	3	40	60	70	80	L	80	> BHB 1.2 mmol/l or loss in BCS >1	10	15	20	M	3.15	30	M
5.1	9	**Inadequate transition feeding**	Inadequate feeding strategy, energy and fibre supply	ketosis, decreased fertility, SARA, immunosuppresssion	2	70	50	60	70	L	45	See S. Report Chapter 10	30	50	70	M	10.50	35	M
5.1	10	**Overfeeding**	Excess of nutrient supply in relation to genotype and energy output at the end of lactation and dry period	ketosis, dystocia, milk fever, downer cow, displaced abomasum, decreased fertility	3	70	30	50	70	L	100	BCS > 3.75 at calving	15	20	25	M	5.25	52.5	M
5.1	11	**Inadequate feeding schedule (poor bunk management)**	frequency and regularity of supplying feed	SARA, ketosis, reduced fertility	1	60	10	20	30	M	325	period of absence of feed >1 h	10	15	20	H	0.45	15	H

Figure 11. Risk assessment hazards related to nutrition and feeding in dairy cows kept in tie-stalls (continued).

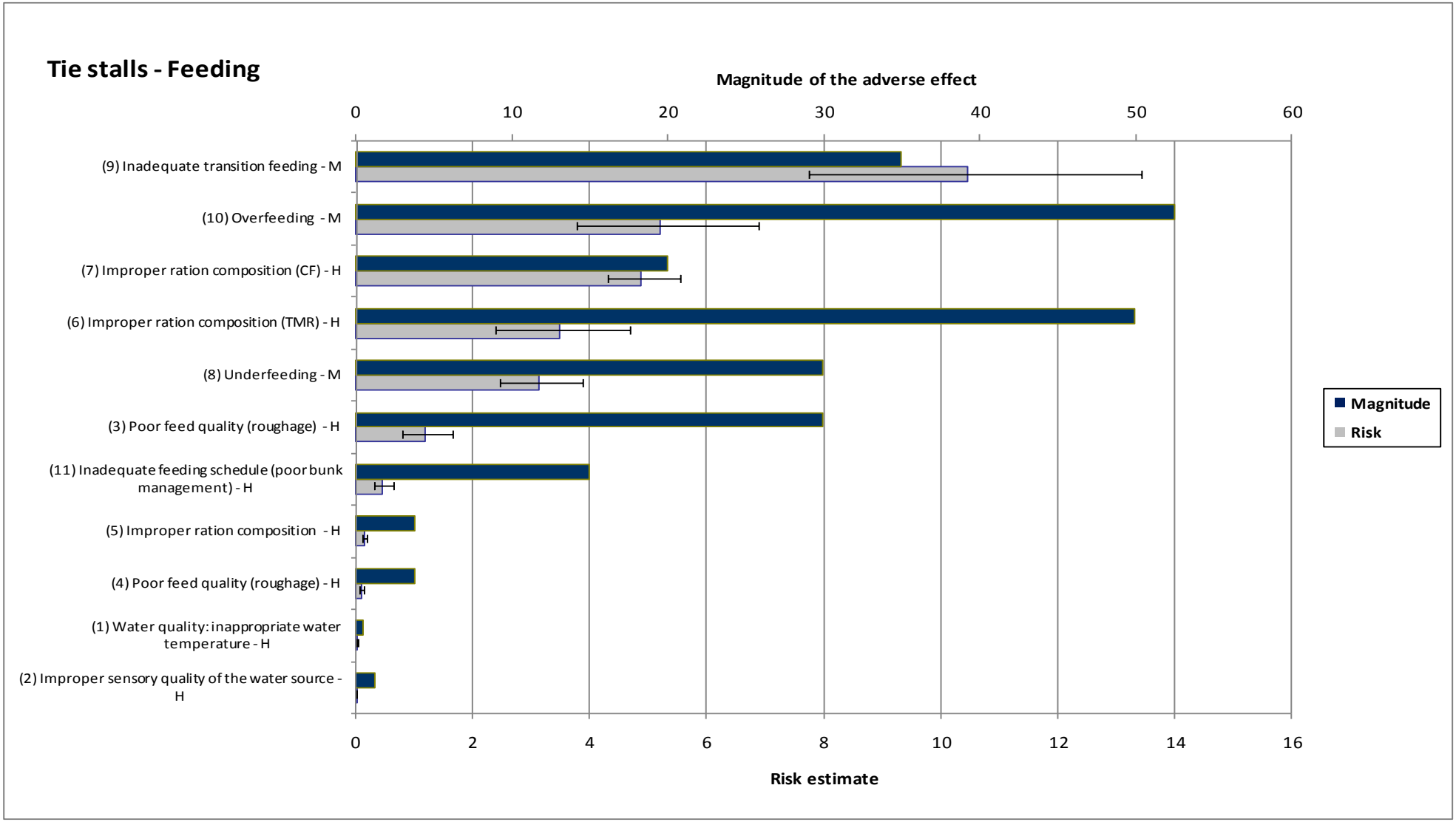

Figure 42. Ranking of hazards related to nutrition and feeding in dairy cows kept in tie-stalls.

TIE -STALLS				MET & REPR															
	Hazard identification			Hazard characterization							Exposure assessment						Risk Characterization		
Chapter of the scient. report	Hazard Nr.	Hazard description	Hazard specification	Adverse effect	Severity of the adverse effect	Duration of the adverse effect	Likelihood of the adverse effect			Uncertainty	Duration of the hazard	Intensity	Likelihood of the exposure to the hazard			Uncertainty	Risk estimate	Magnitude of adverse effect	Qualtitative uncertainty
							min	ml	max				min	ml	max				
MANAGEMENT																			
8.2. / 8.3 / 8.4	1	**Poor calving management**		metritis, dystocia, reduced fertility, prolonged parturition, reduced feed intake, fatty liver, downer cows	3	15	5	10	15	L	5	full exposure	50	60	70	H	0.68	11.25	H
8.1	2	**Mixing animals from different groups**	the single animal is moved to another group	reduced feed intake, ketosis, reproductive failure	1	5	10	15	20	L	5	full exposure	98	99	100	M	0.19	1.25	M
13.1	3	**Insufficient or inappropriate contact with humans**	--	fear, injuries, reproductive and other disorders	2	1	20	50	80	H	365	high % of negative contact	15	25	35	H	0.06	0.5	H
13.1	4	**Insufficient or inappropriate contact with humans**	neglect, lack of knowledge or lack of time	fear, injuries, reproductive and other disorders	1	1	5	10	15	H	365	few or no positive contact	5	10	15	H	0.00	0.25	H
14	5	**Insufficient or inappropriate care of animals by stockperson**	neglect, lack of knowledge or lack of time	disease, prolonged disease, delayed treatment of disease	2	7	60	70	80	M	365	full exposure	20	30	40	H	0.74	3.5	H

Figure 13. Risk assessment hazards related to management in dairy cows kept in tie-stalls.

TIE -STALLS				MET & REPR															
Chapter of the scient. report	Hazard identification			Hazard characterization							Exposure assessment						Risk Characterization		
	Hazard Nr.	Hazard description	Hazard specification	Adverse effect	Severity of the adverse effect	Duration of the adverse effect	Likelihood of the adverse effect			Uncertainty	Duration of the hazard	Intensity	Likelihood of the exposure to the hazard			Uncertainty	Risk estimate	Magnitude of adverse effect	Qualtitative uncertainty
							min	ml	max				min	ml	max				
MANAGEMENT																			
12.3/11.2	6	**Inadequate preventive medicine, herd-health management including health recording**	neglect, lack of knowledge or lack of time	prolonged metabolic disease, delayed treatment of disease, dystocia, reproductive failure	2	10	20	30	40	M	365	full exposure	30	45	60	H	0.68	5	H
12.3	7	**Inappropriate hormonal interventions on groups of animals**	mismatch physiological condition with the treatment	risk of improper treatment, induced abortion, metabolic stress	2	15	50	60	70	H	80	full exposure	2	5	8	H	0.23	7.5	H
12.3	8	**Inadequate biosecurity**	inadequate cleaning (and disinfection) on the farm e.g. floor, quarantine pen, calving pen, milking machine	uterus infection, reproductive failure, abortion	2	30	15	20	25	H	365	full exposure	30	40	50	H	1.20	15	H
12.3	9	**Inadequate biosecurity**	introducing infectious/ diseased cattle (without quarantine and testing) e.g. BVD, Johnes Disease, Leptospira	uterus infection, reproductive failure, abortion, metabolic stress due to disease	3	30	40	60	80	H	5	full exposure	50	70	90	H	9.45	22.5	H
12.3	10	**Inadequate biosecurity**	inadequate control of pest and vectors	uterus infection, reproductive failure, abortion, metabolic stress due to disease	3	30	5	10	15	H	100	full exposure	10	20	30	H	0.45	22.5	H

Figure 13. Risk assessment hazards related to management in dairy cows kept in tie-stalls (continued).

TIE -STALLS				MET & REPR															
Chapter of the scient. report	Hazard identification			Hazard characterization							Exposure assessment						Risk Characterization		
	Hazard Nr.	Hazard description	Hazard specification	Adverse effect	Severity of the adverse effect	Duration of the adverse effect	Likelihood of the adverse effect			Uncertainty	Duration of the hazard	Intensity	Likelihood of the exposure to the hazard			Uncertainty	Risk estimate	Magnitude of adverse effect	Qualtitative uncertainty
							min	ml	max				min	ml	max				
MANAGEMENT																			
12.3/11.2	11	**Witholding necessary veterinary therapeutic health care**	Fairly to identiy and treat diseased animals	including unnecessarily metabolic and reproductive disease, uterus disease, including unnecessarily prolonged disease, early culling	2	15	30	40	50	H	40	full exposure	10	20	30	H	0.60	7.5	H
13.8	12	**Improper operational pain management**	Any surgery (e.g. caesarean, displaced abomasum, obstetric interventions, including foetotomy)	reduced DMI, metabolic disease, reduced fertility	3	5	60	70	80	M	10	full exposure	50	60	70	H	1.58	3.75	H
13.5	13	**Improper obstetric interventions**	pregnancy diagnostic, treatment of metritis, retained placenta, improper use of calf pullers, etc..	uterus infection, metabolic diseases, reduced fertility, culling, death	3	10	60	70	80	M	21	full exposure	10	20	30	H	1.05	7.5	H
13.5	14	**Difficult calving because of the sire**	Dystocia	uterus infection, reduced DMI, metabolic disease, perinatal mortality, culling	2	14	60	70	80	M	1	full exposure	5	10	15	H	0.49	7	H
13.7	15	**Downer cow**	Improper management of downer cows - Lack of: physiotherapy, good bedding, proper facilities and lifting devices	metabolic diseases, culling, death	4	5	98	99	100	L	15	full exposure	0.5	1	1.5	M	0.05	5	M

Figure 13. Risk assessment hazards related to management in dairy cows kept in tie-stalls (continued).

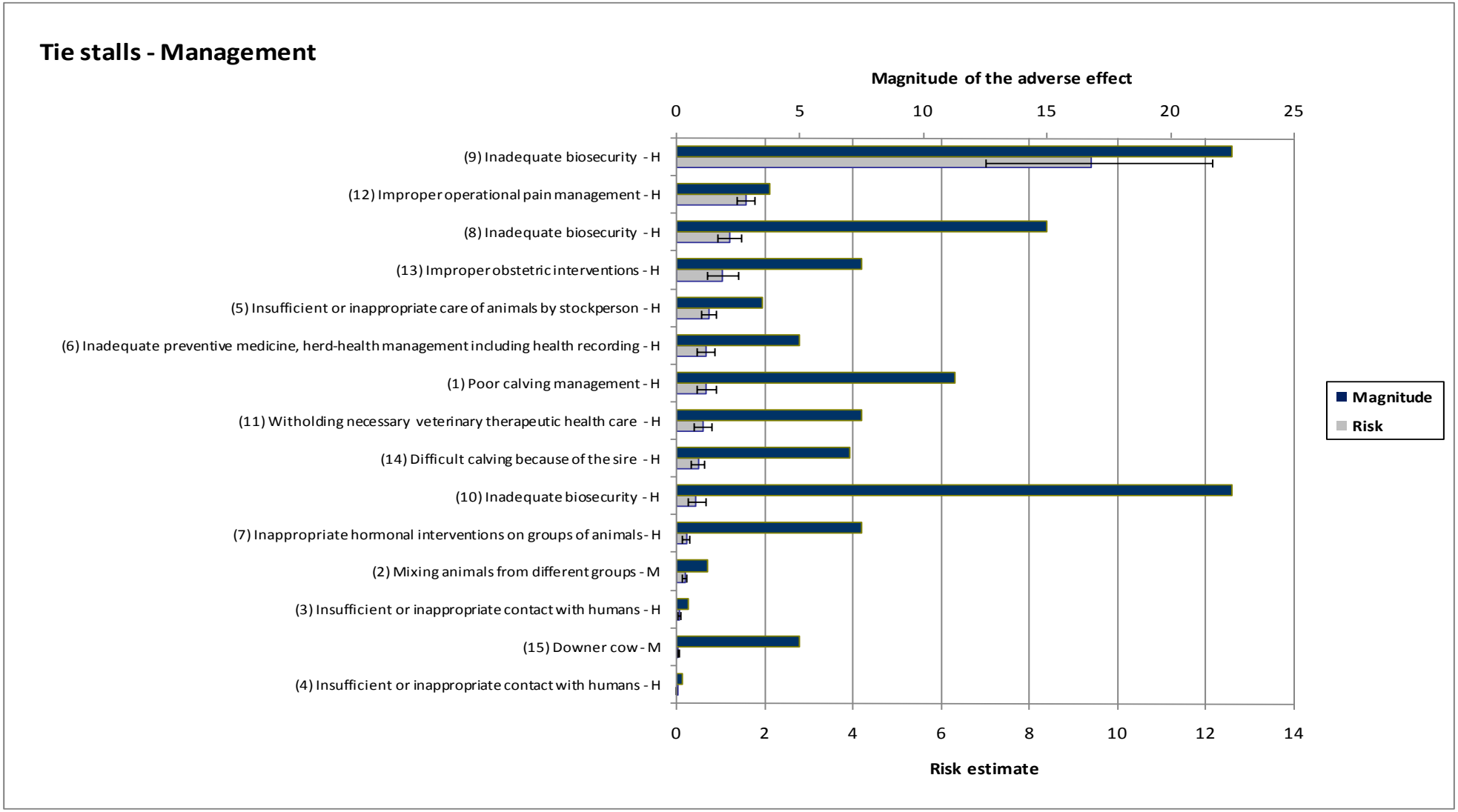

Figure 14. Ranking of hazards related to management in dairy cows kept in tie-stalls.

TIE -STALLS				MET & REPR																
Chapter of the scient. report	Hazard identification			Hazard characterization							Exposure assessment						Risk Characterization		
	Hazard Nr.	Hazard description	Hazard specification	Adverse effect	Severity of the adverse effect	Duration of the adverse effect	Likelihood of the adverse effect			Uncertainty	Duration of the hazard	Intensity	Likelihood of the exposure to the hazard			Uncertainty	Risk estimate	Magnitude of adverse effect	Qualtitative uncertainty
							min	ml	max				min	ml	max				
GENETICS																			
4.2	1	**high genetic potential for production due to selection ignoring other traits**	with good housing, nutrition and management	reproductive disorders	2	40	30	40	50	L	365	estimated breeding value for yield in top quartile for breed and country	20	30	40	H	2.40	20	H
4.2	2	**high genetic potential for production due to selection ignoring other traits**	without good housing, nutrition and management	reproductive disorders	3	60	40	50	60	M	365	estimated breeding value for yield in top quartile for breed and country	25	40	55	H	9.00	45	H
4.2	3	**high genetic potential for production due to selection ignoring other traits**	with good housing, nutrition and management	metabolic disorders	2	60	30	40	50	L	365	estimated breeding value for yield in top quartile for breed and country	20	30	40	H	3.60	30	H
4.2	4	**high genetic potential for production due to selection ignoring other traits**	without good housing, nutrition and management	metabolic disorders	3	80	40	50	60	M	365	estimated breeding value for yield in top quartile for breed and country	25	40	55	H	12.00	60	H

Figure 15. Risk assessment hazards related to genetics in dairy cows kept in tie-stalls.

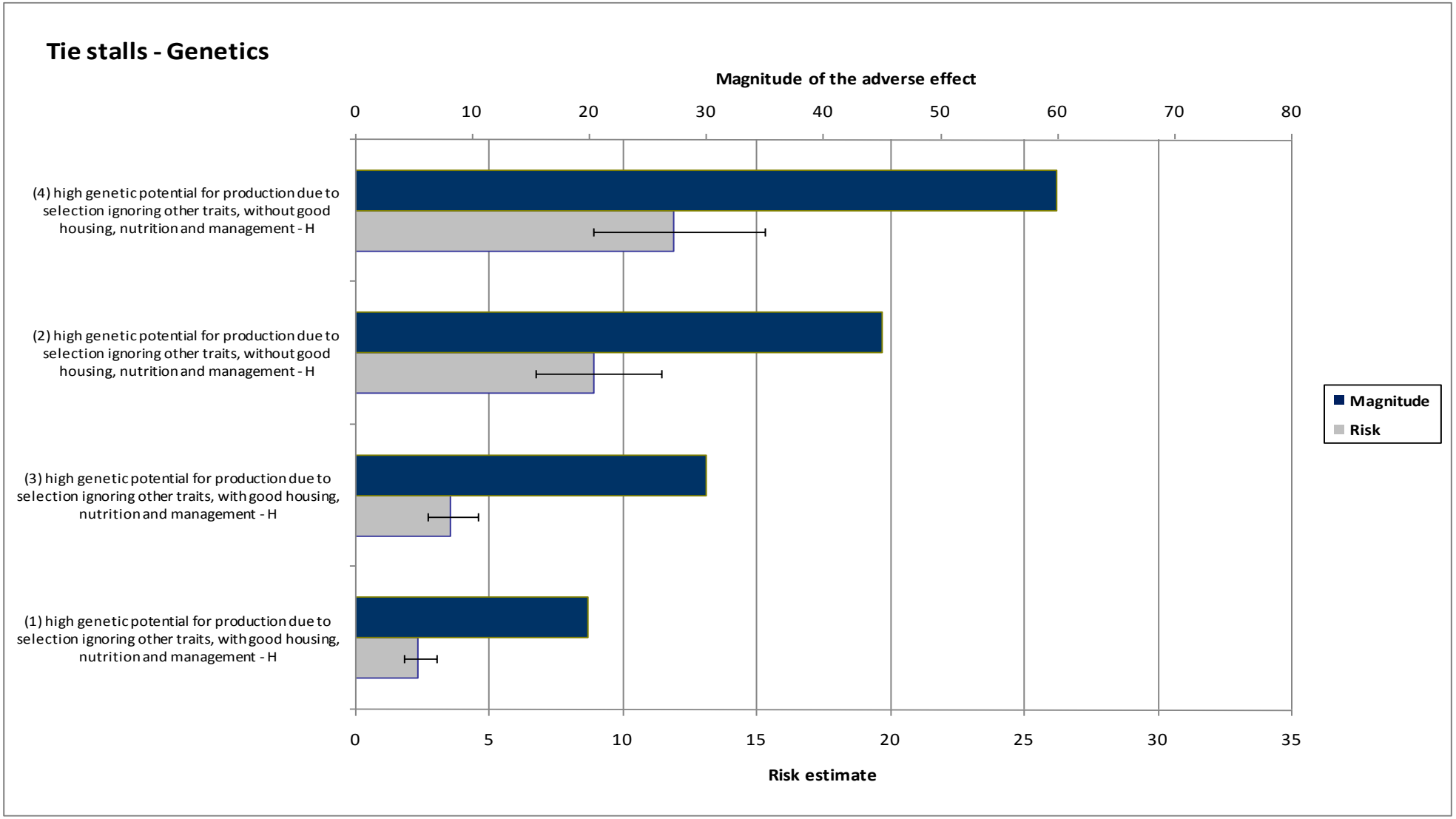

Figure 56. Ranking of hazards related to genetics in dairy cows kept in tie-stalls.

STRAW YARDS				MET & REPR																
Chapter of the scient. report	Hazard identification			Hazard characterization							Exposure assessment						Risk Characterization		
	Hazard Nr.	Hazard description	Hazard specification	Adverse effect	Severity of the adverse effect	Duration of the adverse effect	Likelihood of the adverse effect			Uncertainty	Duration of the hazard	Intensity	Likelihood of the exposure to the hazard			Uncertainty	Risk estimate	Magnitude of adverse effect	Qualtitative uncertainty
							min	ml	max				min	ml	max				
HOUSING																			
6.5.	**1**	**Inadequate ventilation, inappropriate airflow, airspeed**	too low ventilation (1/3 of winter period)	reduced feed intake, immunosuppression, less oestrus expression, reduced fertility, SARA, ketosis.	2	20	25	35	45	M	60	<60 m3 air/500 kg LW/h	5	10	15	M	0.35	10	M
6.5.	**2**	**Inadequate ventilation, inappropriate airflow, airspeed**	too low ventilation (1/3 of indoor period + part of summer)	reduced feed intake, immunosuppression, less oestrus expression, reduced fertility, SARA, ketosis.	3	80	25	35	45	L	120	<60 m3 (300 in summer) air/500 kg LW/h	5	10	15	M	2.10	60	M
6.5.	**3**	**Insufficient light level (day/night)**	too dark (for both cows and stockperson)	reduced disease detection, reduced fertility, sub-optimal feed intake	1	20	0	5	10	H	45	< 40 lux	5	10	15	M	0.03	5	H
6.5.	**4**	**light duration**	too short (<14 h)	reduced fertility, sub-optimal feed intake	1	25	0	2	4	M	60	< 14 h	15	30	50	M	0.04	6.25	M
5.1 / 6.1	**5**	**inadequate feeding installation**	automatic feeder failure	reduced or excessive feed intake, acute ruminal acidosis	4	7	30	50	70	L	1	full exposure	0.1	0.2	0.3	M	0.01	7	M
6.7	**6**	**Inadequate bedding**	hygiene, composition and quantity (in zero-grazing)	SARA, ketosis, reduced fertility, pain	1	60	20	30	40	L	365	full exposure	20	30	40	M	1.35	15	M
6.7	**7**	**Inadequate bedding**	hygiene, composition and quantity (with access to pasture)	SARA, ketosis, reduced fertility, pain	1	20	20	30	40	L	180	full exposure	20	30	40	M	0.45	5	M

Figure 67. Risk assessment hazards related to housing in dairy cows kept in straw yards.

STRAW YARDS				MET & REPR																
Chapter of the scient. report	Hazard identification			Hazard characterization							Exposure assessment						Risk Characterization		
	Hazard Nr.	Hazard description	Hazard specification	Adverse effect	Severity of the adverse effect	Duration of the adverse effect	Likelihood of the adverse effect			Uncertainty	Duration of the hazard	Intensity	Likelihood of the exposure to the hazard			Uncertainty	Risk estimate	Magnitude of adverse effect	Qualtitative uncertainty
							min	ml	max				min	ml	max				
HOUSING																			
6.1	8	**Inadequate floor (limited to passage ways, feeding and milking areas)**	too slippery, too hard, injuring, too rough	ketosis, reduced fertility	1	30	1	5	10	M	365	full exposure	30	50	70	M	0.19	7.5	M
6.2	9	**Lack of space, e.g. for exercising, social interactions and resting**	--	immunosuppression, less oestrus expression, reduced fertility, ketosis	1	30	5	10	15	M	365	full exposure	20	30	40	H	0.23	7.5	H
12.3	10	**Lack of facilities for sick animals**	--	downer cow, (check calving problems in the rest of this table)	2	7	0.5	1	1.5	L	365	full exposure	50	70	90	H	0.02	3.5	H
5.2	11	**Insufficient access to water**	inappropriate system design	reduced dry matter intake, SARA, ketosis	1	120	30	50	70	M	365	any cow can't access water for 5 hours	1	5	10	H	0.75	30	H
5.2	12	**Insufficient access to water**	broken system, management problem, etc…	dehydration, reduced dry matter intake, SARA	2	1	70	80	90	L	1	total lack of water	0	0.1	0.2	H	0.00	0.5	H
13.1	13	**Inadequate or lack of handling/restraining facilities**		reproductive failure, injuries	3	10	0.01	0.1	0.2	H	10	full exposure	30	50	70	H	0.00	7.5	H

Figure 17. Risk assessment hazards related to housing in dairy cows kept in straw yards (continued).

STRAW YARDS				MET & REPR																
Chapter of the scient. report	Hazard identification			Hazard characterization							Exposure assessment							Risk Characterization		
	Hazard Nr.	Hazard description	Hazard specification	Adverse effect	Severity of the adverse effect	Duration of the adverse effect	Likelihood of the adverse effect			Uncertainty	Duration of the hazard	Intensity	Likelihood of the exposure to the hazard			Uncertainty	Risk estimate	Magnitude of adverse effect	Qualtitative uncertainty
							min	ml	max				min	ml	max				
HOUSING																			
6.5	14	**Inappropriate temperature, humidity**		reduced feed intake, ketosis, SARA, reproductive failure	1	20	15	30	45	M	30	75<THI<78	50	60	70	M	0.90	5	M
6.5	15	**Inappropriate temperature, humidity**		dehydration, reduced feed intake, ketosis, SARA, reproductive failure	2	12	40	50	60	M	15	78<THI<83	40	50	60	M	1.50	6	M
6.5	16	**Inappropriate temperature, humidity**		dehydration, reduced feed intake, ketosis, SARA, reproductive failure	3	5	60	80	100	M	5	THI>83	10	15	20	M	0.45	3.75	M
8.2	17	**Poor calving conditions**	absence of pen, pen design, facilities (inability to separate from other animals)	metritis, dystocia, reduced fertility, prolonged parturition, reduced feed intake, fatty liver, downer cows	1	21	10	15	20	L	7	full exposure	30	50	70	H	0.39	5.25	H
5.1 / 6.1	18	**too few feeding places in zero grazing systems**	--	reduced feed intake, ketosis, SARA, reproductive failure	2	60	5	10	15	L	365	> 1 cow per place	5	10	15	H	0.30	30	H
5.1 / 6.1	19	**too few feeding places (cows with access to pasture)**	--	reduced feed intake, ketosis, SARA, reproductive failure	2	60	5	10	15	L	215	> 1 cow per place	10	20	30	H	0.60	30	H

Figure 17. Risk assessment hazards related to housing in dairy cows kept in straw yards (continued).

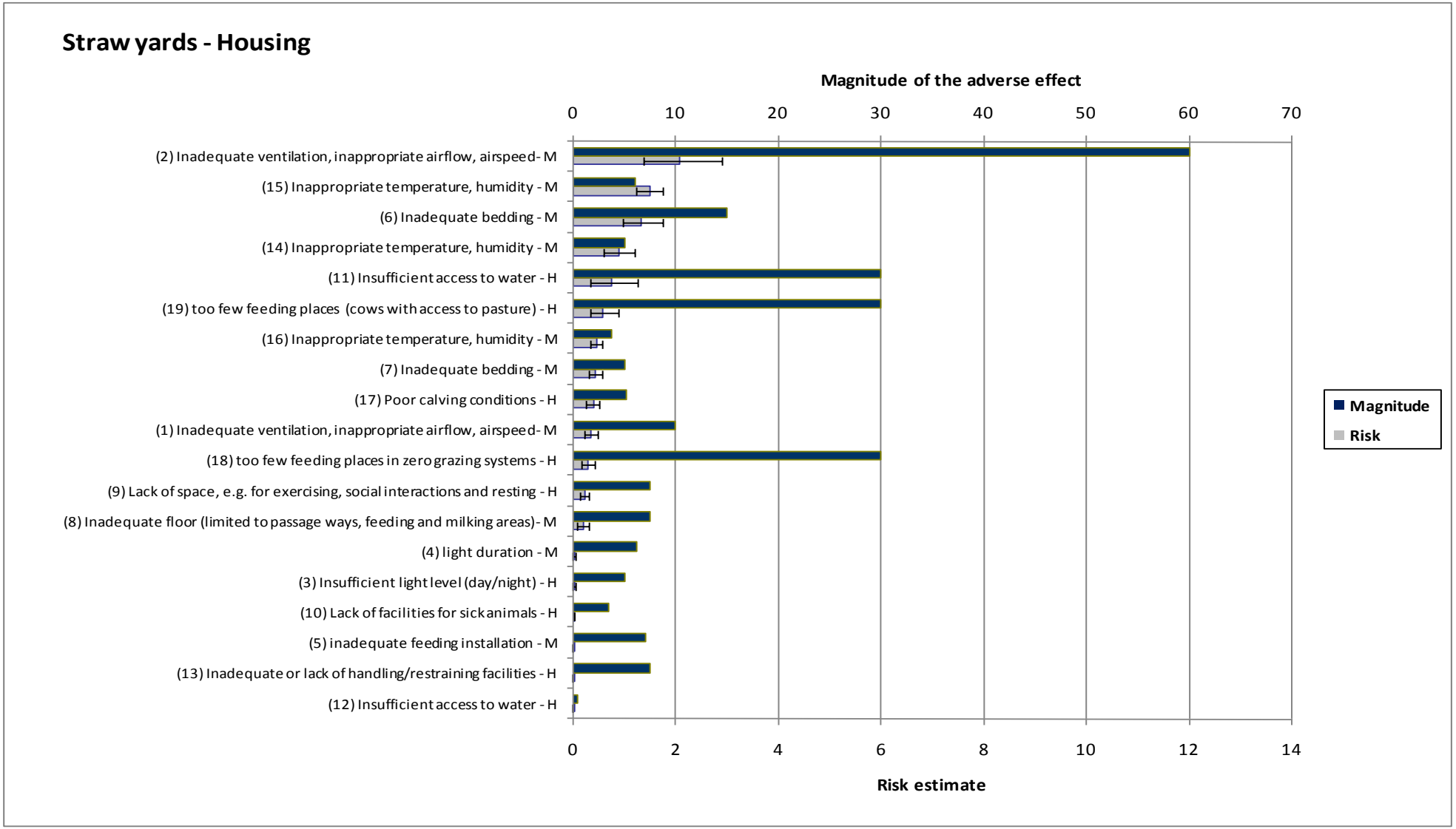

Figure 18. Ranking of hazards related to housing in dairy cows kept in straw yards.

STRAW YARDS			MET & REPR																
Chapter of the scient. report	Hazard identification			Hazard characterization							Exposure assessment						Risk Characterization		
	Hazard Nr.	Hazard description	Hazard specification	Adverse effect	Severity of the adverse effect	Duration of the adverse effect	Likelihood of the adverse effect			Uncertainty	Duration of the hazard	Intensity	Likelihood of the exposure to the hazard			Uncertainty	Risk estimate	Magnitude of adverse effect	Qualtitative uncertainty
							min	ml	max				min	ml	max				
NUTRITION AND FEEDING																			
5.2	1	**Water quality: inappropriate water temperature**	too high or too low	dehydration, reduced feed intake, ketosis, SARA, reproductive failure	1	2	5	10	15	M	60	< 5 C or > 25 C	10	20	30	H	0.01	0.5	H
5.2	2	**Improper sensory quality of the water source**	salt, iron, pollutants	dehydration, reduced feed intake, ketosis, reproductive failure	1	5	3	5	7	M	365	> 3000 ppm total dissolved solids	1	5	10	H	0.00	1.25	H
5.1	3	**Poor feed quality (roughage)**	Poor nutritive value, Improper sensory quality of feed	reduced feed intake, ketosis, reproductive failure	2	60	30	40	50	L	100	Ammonia, butiric acid levels	5	10	15	H	1.20	30	H
5.1	4	**Poor feed quality (roughage)**	prevalence of pathogen and toxic substances affecting cattle	ketosis, reproductive failure	1	15	5	10	15	M	100	i.e. presence of Listeria, butolinus toxine, mycotoxines	15	25	35	H	0.09	3.75	H
5.1	5	**Improper ration composition**	inadequate protein/carbohydrate ratio	ketosis, reproductive failure	1	15	10	15	20	L	325	urea in milk <150 ppm or >350 ppm	15	25	35	H	0.14	3.75	H
5.1	6	**Improper ration composition (TMR)**	Inadequate fibre/carbohydrate ratio and fibre quality/length	SARA, reproductive failure	2	100	60	70	80	L	325	rumen pH < 5.8 more than 3 hours	1	5	10	H	1.75	50	H

Figure 19. Risk assessment hazards related to nutrition and feeding in dairy cows kept in straw yards.

STRAW YARDS				MET & REPR															
Chapter of the scient. report	Hazard identification			Hazard characterization							Exposure assessment						Risk Characterization		
	Hazard Nr.	Hazard description	Hazard specification	Adverse effect	Severity of the adverse effect	Duration of the adverse effect	Likelihood of the adverse effect			Uncertainty	Duration of the hazard	Intensity	Likelihood of the exposure to the hazard			Uncertainty	Risk estimate	Magnitude of adverse effect	Qualtitative uncertainty
							min	ml	max				min	ml	max				
NUTRITION AND FEEDING																			
5.1	7	**Improper ration composition (CF)**	Inadequate fibre/carbohydrate ratio and fibre quality/length	SARA, reproductive failure	2	40	60	70	80	L	120	rumen pH < 5.8 more than 3 hours	1	5	10	H	0.70	20	H
5.1	8	**Underfeeding**	including inadequate nutrient supply in relation to genotype and energy output	ketosis, exhaustion, decreased fertility, immunosuppresssion	3	40	60	70	80	L	80	> BHB 1.2 mmol/l or loss in BCS >1	10	25	40	M	5.25	30	M
5.1	9	**Inadequate transition feeding**	Inadequate feeding strategy, energy and fibre supply	ketosis, decreased fertility, SARA, immunosuppresssion	2	70	50	60	70	L	45	See S. Report Chapter 10	30	50	70	M	10.50	35	M
5.1	10	**Overfeeding**	excess of nutrient supply in relation to genotype and energy output at the end of lactation and dry period	ketosis, dystocia, milk fever, downer cow, displaced abomasum, decreased fertility	3	70	30	50	70	L	100	BCS > 3.75 at calving	15	20	25	M	5.25	52.5	M
5.1	11	**Inadequate feeding schedule (poor bunk management)**	frequency and regularity of supplying feed	SARA, ketosis, reduced fertility	1	60	10	20	30	M	325	period of absence of feed >1 h	5	10	15	H	0.30	15	H

Figure 19. Risk assessment hazards related to nutrition and feeding in dairy cows kept in straw yards (continued).

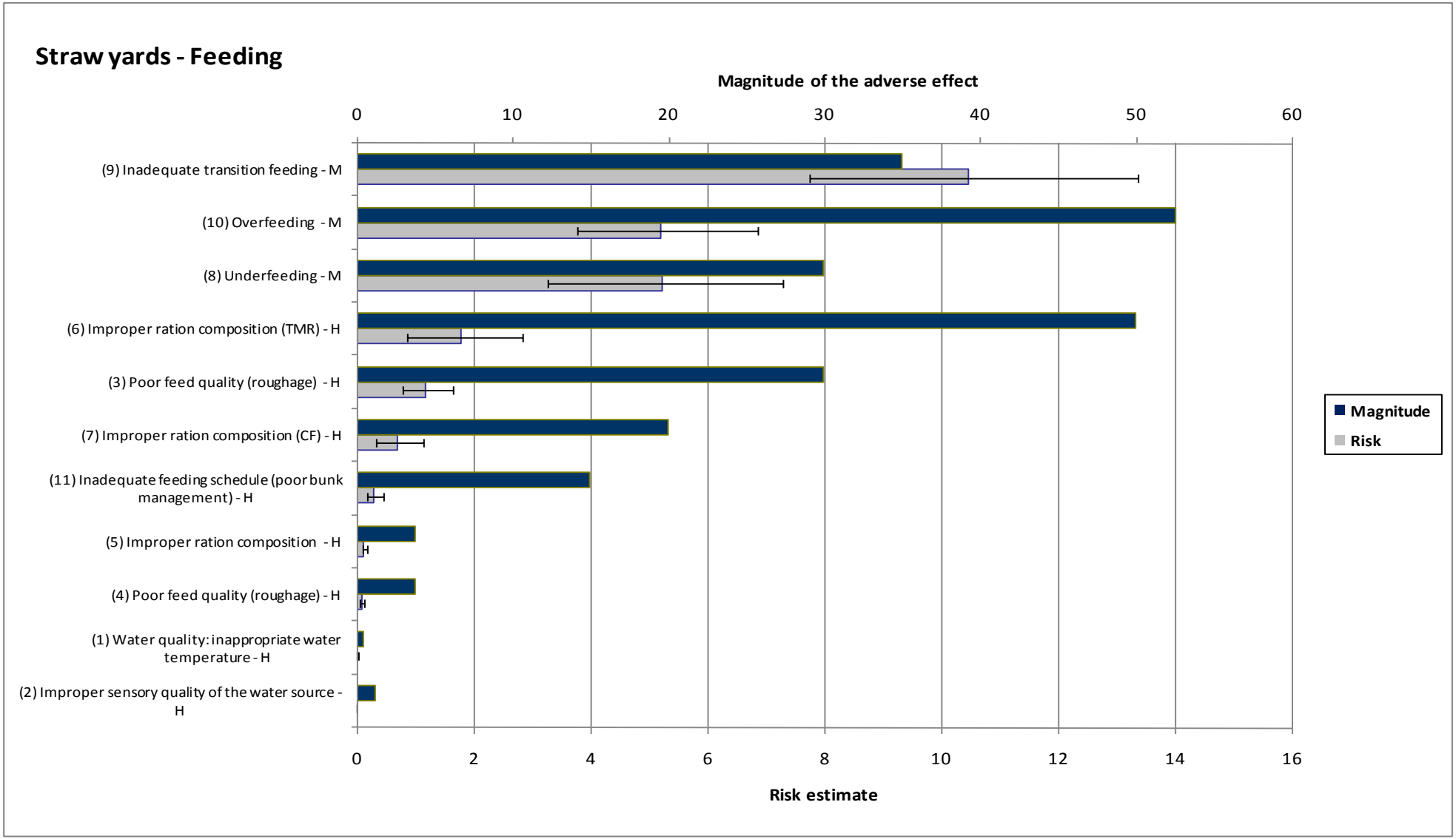

Figure 20. Ranking of hazards related to nutrition and feeding in dairy cows kept in straw yards.

STRAW YARDS				MET & REPR																
Chapter of the scient. report	Hazard identification			Hazard characterization							Exposure assessment						Risk Characterization		
	Hazard Nr.	Hazard description	Hazard specification	Adverse effect	Severity of the adverse effect	Duration of the adverse effect	Likelihood of the adverse effect			Uncertainty	Duration of the hazard	Intensity	Likelihood of the exposure to the hazard			Uncertainty	Risk estimate	Magnitude of adverse effect	Qualtitative uncertainty
							min	ml	max				min	ml	max				
MANAGEMENT																			
8.2. / 8.3 / 8.4	1	**Poor calving management**		metritis, dystocia, reduced fertility, prolonged parturition, reduced feed intake, fatty liver, downer cows	2	15	5	10	15	L	5	full exposure	40	50	60	H	0.38	7.5	H
8.1	2	**Mixing animals from different groups**	the single animal is moved to another group	reduced feed intake, ketosis, reproductive failure	2	5	30	40	50	L	5	full exposure	98	99	100	M	0.99	2.5	M
8.1	3	**Mixing animals from different groups (big farms: > 100 cows)**	the group receiving new animals	reduced feed intake, ketosis, reproductive failure	1	10	3	5	7	M	190	full exposure	60	70	80	M	0.09	2.5	M
8.1	4	**Mixing animals from different groups (small farms < 100 cows)**	the group receiving new animals	injuries, fear, reproductive disorders, other diseases	1	7	6	10	14	M	30	full exposure	20	30	40	M	0.05	1.75	M

Figure 21. Risk assessment hazards related to management in dairy cows kept in straw yards.

STRAW YARDS				MET & REPR															
Chapter of the scient. report	Hazard identification			Hazard characterization							Exposure assessment						Risk Characterization		
	Hazard Nr.	Hazard description	Hazard specification	Adverse effect	Severity of the adverse effect	Duration of the adverse effect	Likelihood of the adverse effect			Uncertainty	Duration of the hazard	Intensity	Likelihood of the exposure to the hazard			Uncertainty	Risk estimate	Magnitude of adverse effect	Qualtitative uncertainty
							min	ml	max				min	ml	max				
MANAGEMENT																			
13.1	5	**Insufficient or inappropriate contact with humans**	neglect, lack of knowledge or lack of time	fear, injuries, reproductive and other disorders	2	1	20	50	80	H	365	high % of negative contact	15	25	35	H	0.06	0.5	H
13.1	6	**Insufficient or inappropriate contact with humans**	neglect, lack of knowledge or lack of time	fear, injuries, reproductive and other disorders	1	1	5	10	15	H	365	few or no positive contact	20	30	40	H	0.01	0.25	H
14	7	**Insufficient or inappropriate care of animals by stockperson**	neglect, lack of knowledge or lack of time	disease, prolonged disease, delayed treatment of disease	2	7	60	70	80	M	365	full exposure	20	30	40	H	0.74	3.5	H
12.3/11.2	8	**Inadequate preventive medicine, herd-health management including health recording**	neglect, lack of knowledge or lack of time	prolonged metabolic disease, delayed treatment of disease, dystocia, reproductive failure	2	10	20	30	40	M	365	full exposure	30	45	60	H	0.68	5	H
12.3	9	**Inappropriate hormonal interventions on groups of animals**	mismatch physiological condition with the treatment	risk of improper treatment, induced abortion, metabolic stress	2	15	50	60	70	H	80	full exposure	2	5	8	H	0.23	7.5	H

Figure 21. Risk assessment hazards related to management in dairy cows kept in straw yards (continued).

STRAW YARDS				MET & REPR																
Chapter of the scient. report	Hazard identification			Hazard characterization							Exposure assessment						Risk Characterization		
	Hazard Nr.	Hazard description	Hazard specification	Adverse effect	Severity of the adverse effect	Duration of the adverse effect	Likelihood of the adverse effect			Uncertainty	Duration of the hazard	Intensity	Likelihood of the exposure to the hazard			Uncertainty	Risk estimate	Magnitude of adverse effect	Qualtitative uncertainty
							min	ml	max				min	ml	max				
MANAGEMENT																			
12.3	10	**Inadequate biosecurity**	inadequate cleaning (and disinfection) on the farm e.g. floor, cubicles, quarantine pen, calving pen, milking machine	uterus infection, reproductive failure, abortion	2	30	15	20	25	H	365	full exposure	40	60	80	H	1.80	15	H
12.3	11	**Inadequate biosecurity**	introducing infectious/diseased cattle (without quarantine and testing) e.g. BVD, Johnes Disease, Leptospira	uterus infection, reproductive failure, abortion, metabolic stress due to disease	3	30	40	60	80	H	5	full exposure	50	70	90	H	9.45	22.5	H
12.3	12	**Inadequate biosecurity**	inadequate control of pest and vectors	uterus infection, reproductive failure, abortion, metabolic stress due to disease	3	30	5	10	15	H	100	full exposure	10	20	30	H	0.45	22.5	H

Figure 21. Risk assessment hazards related to management in dairy cows kept in straw yards (continued).

STRAW YARDS				MET & REPR																
Chapter of the scient. report	Hazard identification			Hazard characterization							Exposure assessment						Risk Characterization		
	Hazard Nr.	Hazard description	Hazard specification	Adverse effect	Severity of the adverse effect	Duration of the adverse effect	Likelihood of the adverse effect			Uncertainty	Duration of the hazard	Intensity	Likelihood of the exposure to the hazard			Uncertainty	Risk estimate	Magnitude of adverse effect	Qualtitative uncertainty
							min	ml	max				min	ml	max				
MANAGEMENT																			
12.3/ 11.2	**13**	**Witholding necessary veterinary therapeutic health care**		including unnecessarily metabolic and reproductive disease, uterus disease, including unnecessarily prolonged disease, early culling	2	15	30	40	50	H	40	full exposure	20	30	40	H	0.90	7.5	H
13.8	**14**	**Improper operational pain management**	Any surgery (e.g. caesarean, displaced abomasum, obstetric interventions, including foetotomy)	reduced DMI, metabolic disease, reduced fertility	3	5	60	70	80	M	10	full exposure	50	60	70	H	1.58	3.75	H
13.5	**15**	**Improper obstetric interventions**		uterus infection, metabolic diseases, reduced fertility, culling, death	3	10	60	70	80	M	21	full exposure	10	20	30	H	1.05	7.5	H
13.5	**16**	**Difficult calving because of the sire**	Dystocia	uterus infection, reduced DMI, metabolic disease, perinatal mortality, culling	2	14	60	70	80	M	1	full exposure	5	10	15	H	0.49	7	H
13.7	**17**	**Downer cow**	Improper management of downer cows - Lack of: physiotherapy, good bedding, proper facilities and lifting devices	metabolic diseases, culling, death	4	5	98	99	100	L	15	full exposure	0.5	1	1.5	M	0.05	5	M

Figure 21. Risk assessment hazards related to management in dairy cows kept in straw yards (continued).

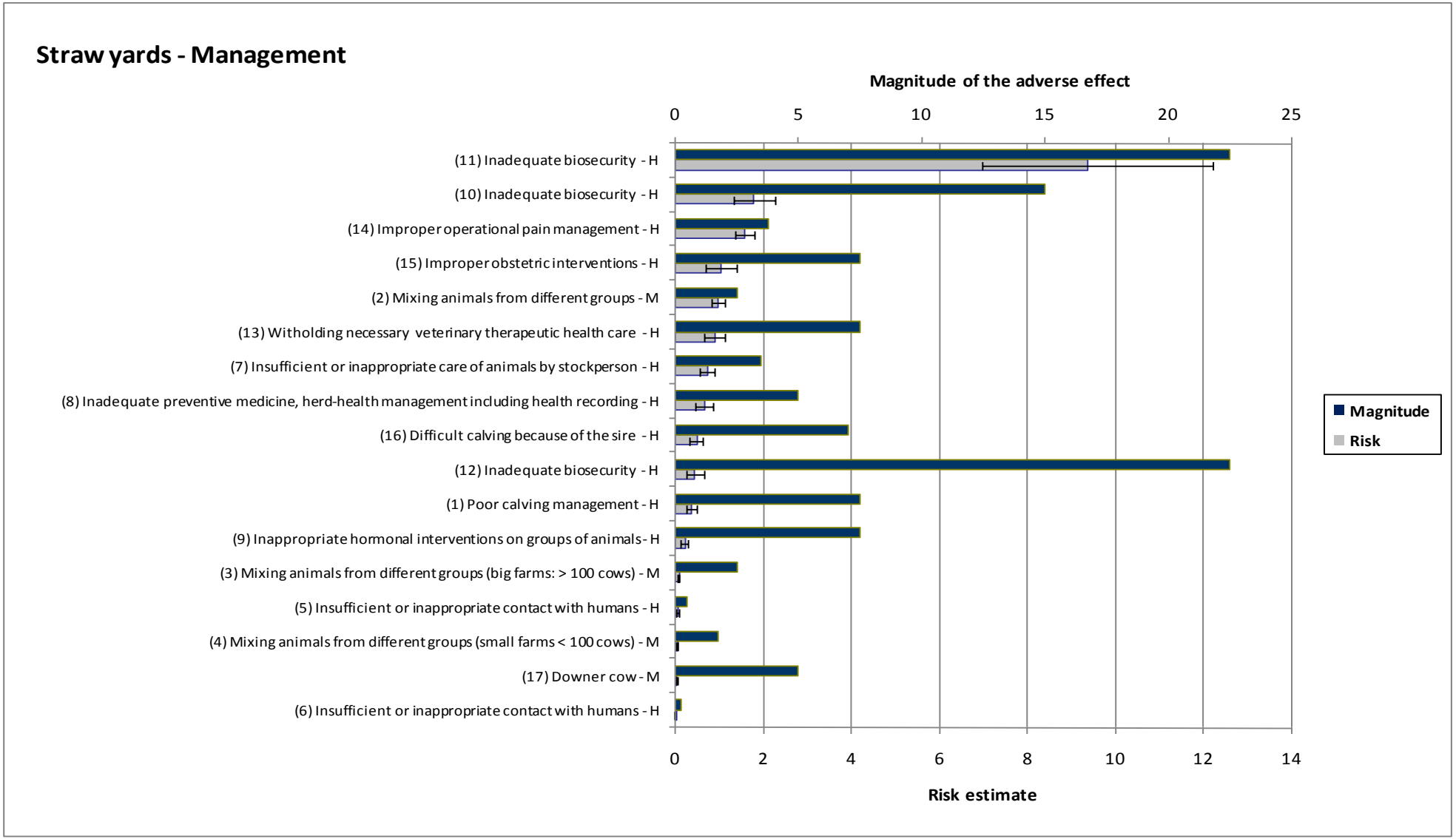

Figure 22. Ranking of hazards related to management in dairy cows kept in straw yards.

STRAW YARDS				MET & REPR																
Chapter of the scient. report	Hazard identification			Hazard characterization							Exposure assessment						Risk Characterization		
	Hazard Nr.	Hazard description	Hazard specification	Adverse effect	Severity of the adverse effect	Duration of the adverse effect	Likelihood of the adverse effect			Uncertainty	Duration of the hazard	Intensity	Likelihood of the exposure to the hazard			Uncertainty	Risk estimate	Magnitude of adverse effect	Qualtitative uncertainty
							min	ml	max				min	ml	max				
GENETICS																			
4.2	1	**high genetic potential for production due to selection ignoring other traits**	with good housing, nutrition and management	reproductive disorders	2	40	20	30	40	L	365	estimated breeding value for yield in top quartile for breed and country	20	30	40	H	1.80	20	H
4.2	2	**high genetic potential for production due to selection ignoring other traits**	without good housing, nutrition and management	reproductive disorders	3	60	30	40	50	M	365	estimated breeding value for yield in top quartile for breed and country	20	40	60	H	7.20	45	H
4.2	3	**high genetic potential for production due to selection ignoring other traits**	with good housing, nutrition and management	metabolic disorders	2	60	20	30	40	L	365	estimated breeding value for yield in top quartile for breed and country	20	30	40	H	2.70	30	H
9.2	4	**high genetic potential for production due to selection ignoring other traits**	without good housing, nutrition and management	metabolic disorders	3	80	30	40	50	M	365	estimated breeding value for yield in top quartile for breed and country	20	40	60	H	9.60	60	H

Figure 23. Risk assessment hazards related to genetics in dairy cows kept in straw yards.

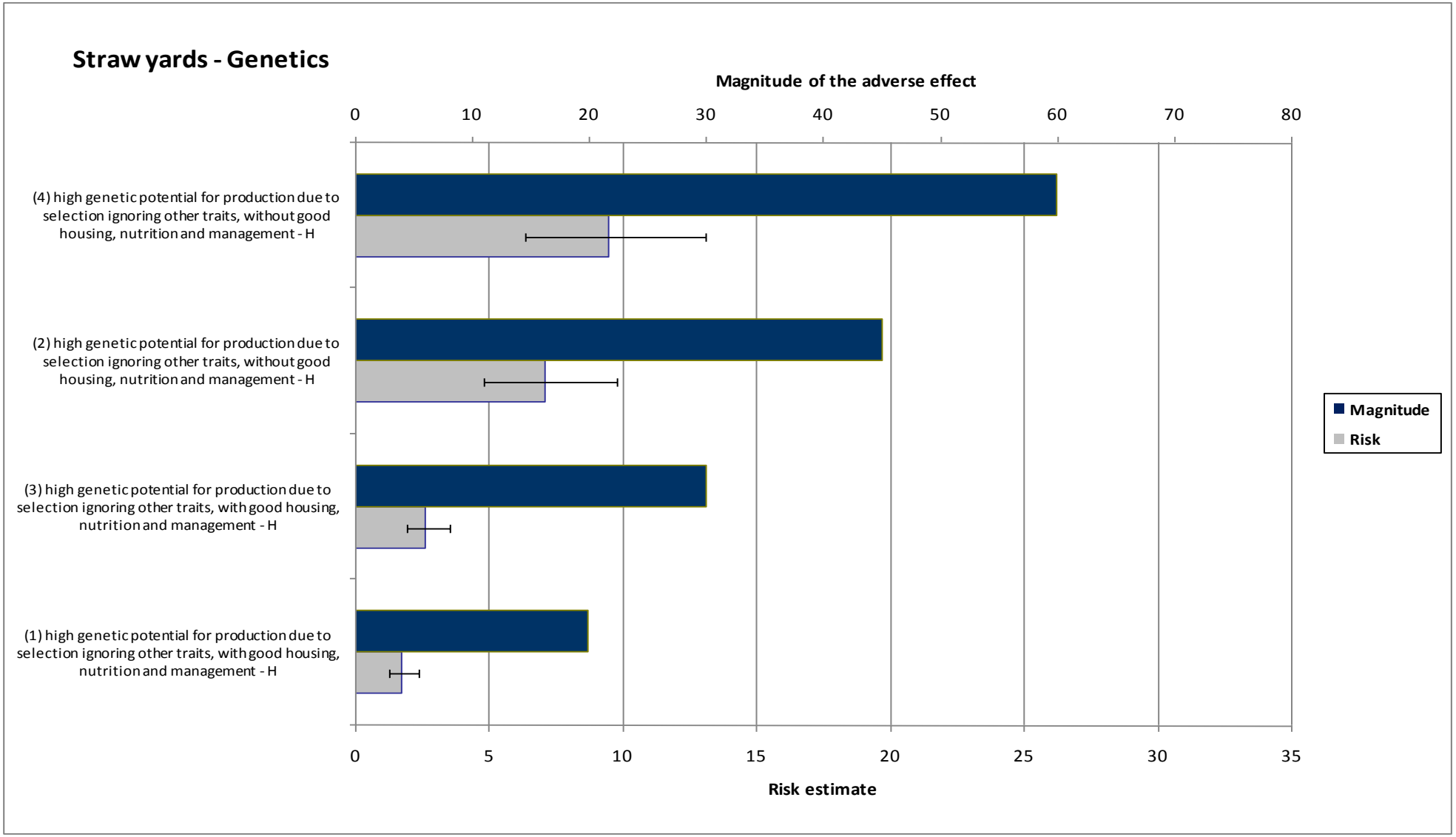

Figure 24. Ranking of hazards related to genetics in dairy cows kept in straw yards.

PASTURE				MET & REPR															
Chapter of the scient. report	Hazard identification			Hazard characterization							Exposure assessment						Risk Characterization		
	Hazard Nr.	Hazard description	Hazard specification	Adverse effect	Severity of the adverse effect	Duration of the adverse effect	Likelihood of the adverse effect			Uncertainty	Duration of the hazard	Intensity	Likelihood of the exposure to the hazard			Uncertainty	Risk estimate	Magnitude of adverse effect	Qualitative uncertainty
							min	ml	max				min	ml	max				
HOUSING																			
6.1	1	**Walking tracks too long, or poorly maintained**	pathways uneven or stony.	ketosis, reduced fertility, reduced oestrus expression	2	10	15	20	25	H	180	> 0.5 Km	5	15	25	M	0.15	5	H
12.3	2	**Lack of facilities for sick animals**	Including facility on the farm	downer cow, (check calving problems in the rest of this table)	2	7	0.5	1	1.5	H	180	full exposure	10	15	20	H	0.00525	3.5	H
5.2	3	**Insufficient access to water**	inappropriate system design	reduced dry matter intake, SARA, ketosis	2	1	20	30	40	M	180	more than 5 hours water deprivation	20	25	30	H	0.0375	0.5	H
5.2	4	**Insufficient access to water**	broken system, management problem, etc…	dehydration, reduced dry matter intake, SARA	2	1	20	30	40	M	1	total lack of water	0	0.1	0.2	H	0.00015	0.5	H
13.1	5	**Inadequate or lack of handling/restraining facilities**	Milking facilities used for restrain/handling	reproductive failure, injuries	1	1	1	2	3	H	10	full exposure	30	50	70	H	0.0025	0.25	H
6.5	6	**Inappropriate temperature, humidity**	Insufficent/absent shade	dehydration, reduced feed intake, ketosis, SARA, reproductive failure	2	3	15	20	25	M	180	Exposed to >25 C and direct sun > 6 h	70	80	90	H	0.24	1.5	H
8.2	7	**Poor calving conditions**	absence of pen, pen design, facilities (inability to separate from other animals)	metritis, dystocia, reduced fertility, prolonged parturition, reduced feed intake, fatty liver, downer cows	1	1	2	3	4	M	7	full exposure	40	50	60	M	0.00375	0.25	M

Figure 25. Risk assessment hazards related to housing in dairy cows kept in pasture.

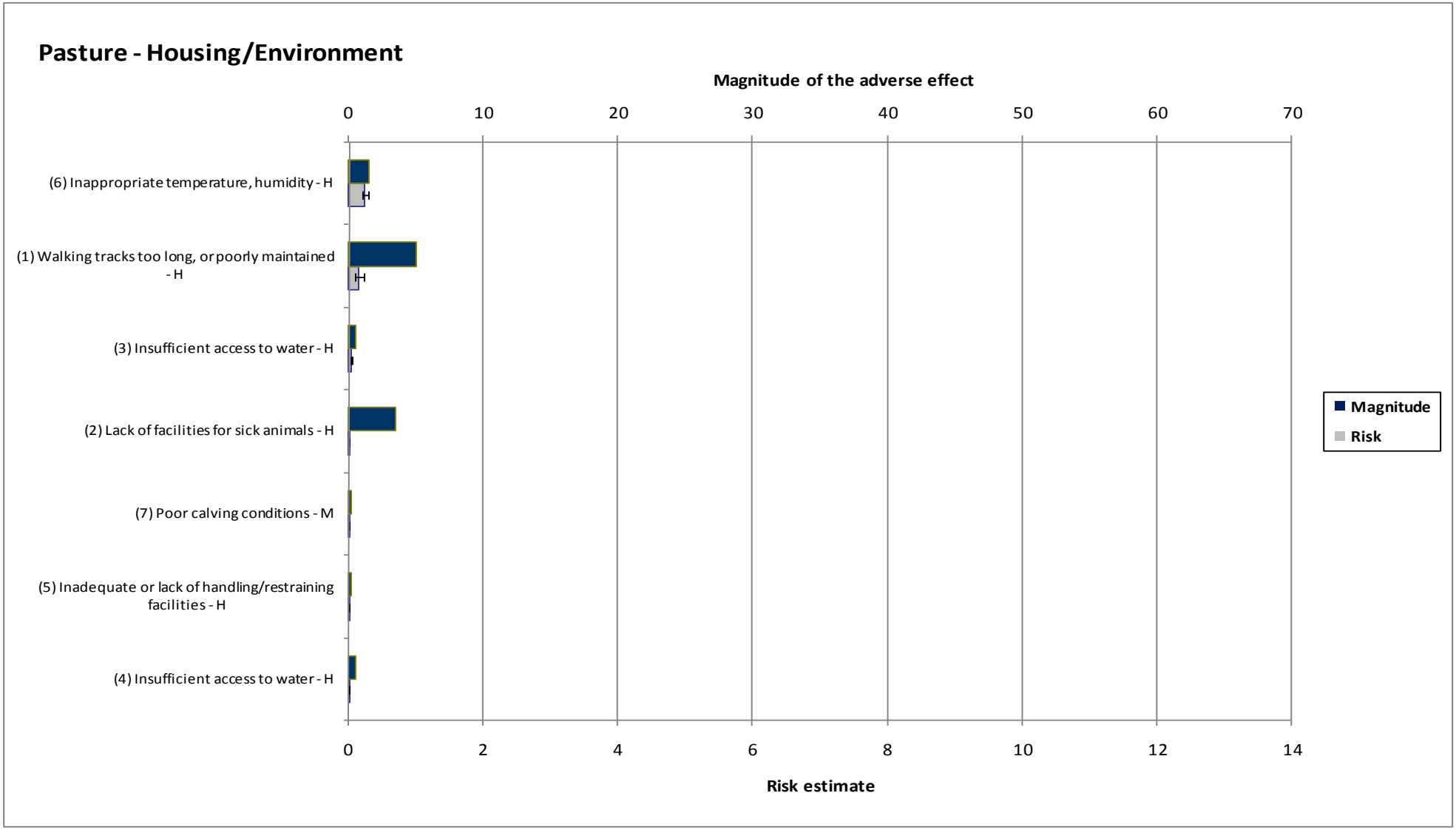

Figure 26. Ranking of hazards related to housing in dairy cows kept in pasture.

PASTURE				MET & REPR															
	Hazard identification			Hazard characterization							Exposure assessment						Risk Characterization		
Chapter of the scient. report	Hazard Nr.	Hazard description	Hazard specification	Adverse effect	Severity of the adverse effect	Duration of the adverse effect	Likelihood of the adverse effect			Uncertainty	Duration of the hazard	Intensity	Likelihood of the exposure to the hazard			Uncertainty	Risk estimate	Magnitude of adverse effect	Qualtitative uncertainty
							min	ml	max				min	ml	max				
NUTRITION AND FEEDING																			
5.2	1	**Water quality: inappropriate water temperature**	too high or too low	dehydration, reduced feed intake, ketosis, SARA, reproductive failure	1	2	5	10	15	M	60	< 5 C or > 25 C	5	10	15	H	0.005	0.5	H
5.2	2	**Improper sensory quality of the water source**	salt, iron, pollutants	dehydration, reduced feed intake, ketosis, reproductive failure	1	5	3	5	7	M	180	> 3000 ppm total dissolved solids	1	5	10	H	0.003125	1.25	H
5.1	3	**Improper ration composition**	inadequate protein/carbohydrate ratio	ketosis, reproductive failure	1	15	10	15	20	L	90	urea in milk <150 ppm or >350 ppm	15	30	45	M	0.16875	3.75	M
5.1	4	**Improper ration composition**	Inadequate fibre/carbohydrate ratio and fibre quality/length	SARA, reproductive failure	1	15	10	15	20	L	90	rumen pH < 5.8	10	15	20	M	0.084375	3.75	M
5.1	5	**Underfeeding**	including inadequate nutrient supply in relation to genotype and energy output. Also in case of poor nutritive value	ketosis, exhaustion, decreased fertility, immunosuppresssion	2	40	60	70	80	L	80	> BHB 1.2 mmol/l or loss in BCS >1	10	25	40	M	3.5	20	M
5.1	6	**Overfeeding**	excess of nutrient supply in relation to genotype and energy output at the end of lactation and dry period	ketosis, dystocia, milk fever, downer cow, displaced abomasum, decreased fertility	2	70	30	50	70	M	90	BCS > 3.75 at calving	1	5	10	H	0.875	35	H

Figure 27. Risk assessment hazards related to nutrition and feeding in dairy cows kept in pasture.

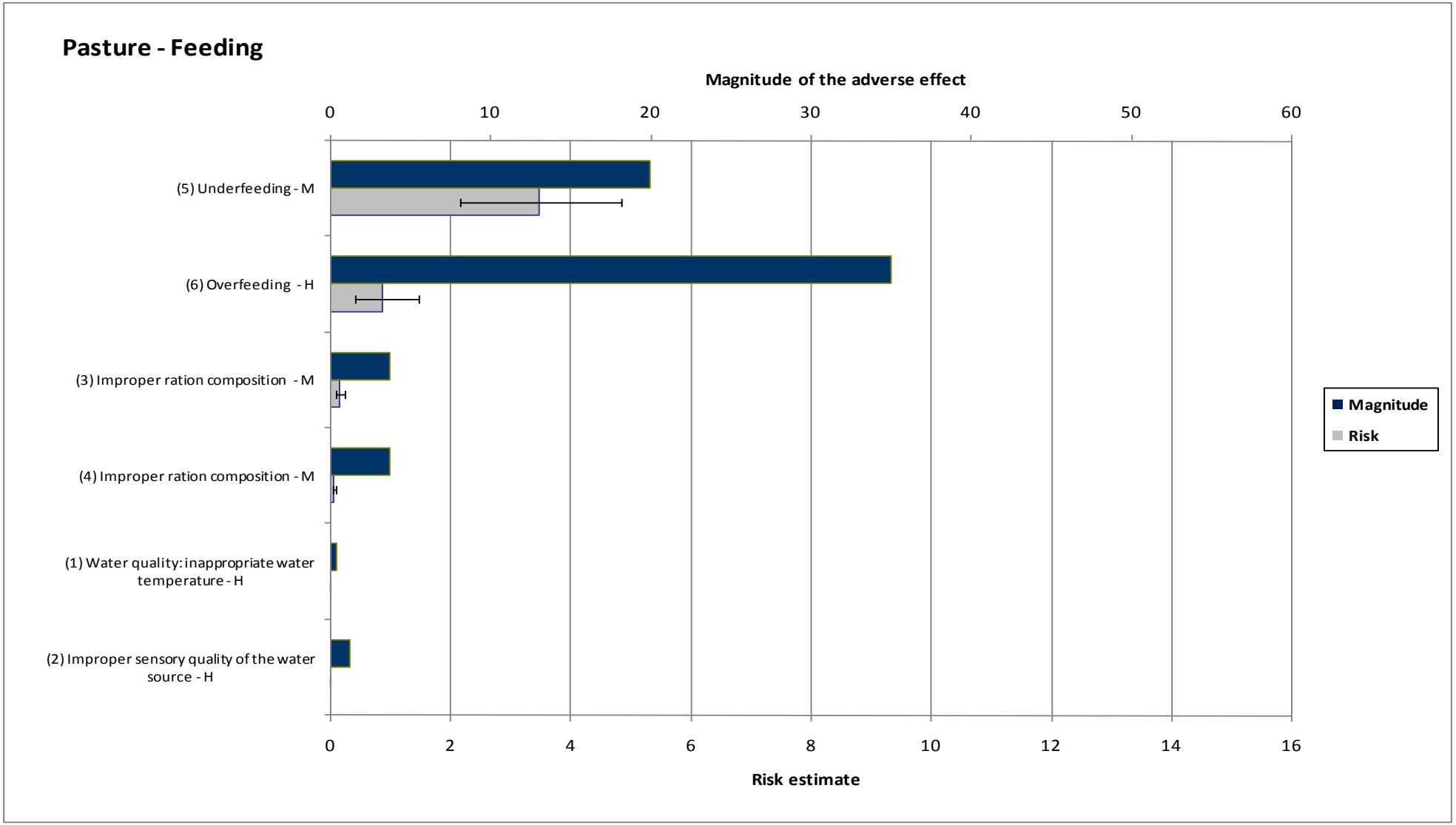

Figure 28. Ranking of hazards related to nutrition and feeding in dairy cows kept in pasture.

PASTURE				MET & REPR																
	Hazard identification			Hazard characterization							Exposure assessment						Risk Characterization		
Chapter of the scient. report	Hazard Nr.	Hazard description	Hazard specification	Adverse effect	Severity of the adverse effect	Duration of the adverse effect	Likelihood of the adverse effect			Uncertainty	Duration of the hazard	Intensity	Likelihood of the exposure to the hazard			Uncertainty	Risk estimate	Magnitude of adverse effect	Qualtitative uncertainty
							min	ml	max				min	ml	max				
MANAGEMENT																			
8.2. / 8.3 / 8.4	1	**Poor calving management**		metritis, dystocia, reduced fertility, prolonged parturition, reduced feed intake, fatty liver, downer cows	3	15	3	7	10	H	5	full exposure	60	70	80	H	0.55125	11.25	H
8.1	2	**Mixing animals from different groups**	the single animal is moved to another group	reduced feed intake, ketosis, reproductive failure	2	5	5	10	15	M	5	full exposure	5	10	20	M	0.025	2.5	M
8.1	3	**Mixing animals from different groups (big farms: > 100 cows)**	the group receiving new animals	reduced feed intake, ketosis, reproductive failure	1	5	3	5	7	M	60	full exposure	10	20	30	M	0.0125	1.25	M
8.1	4	**Mixing animals from different groups (small farms < 100 cows)**	the group receiving new animals	injuries, fear, reproductive disorders, other diseases	1	5	3	5	7	M	60	full exposure	10	20	30	M	0.0125	1.25	M
13.1	5	**Insufficient or inappropriate contact with humans**	neglect, lack of knowledge or lack of time	fear, injuries, reproductive and other disorders	1	1	5	10	15	H	180	high % of negative contact	10	15	20	H	0.00375	0.25	H

Figure 29. Risk assessment hazards related to management in dairy cows kept in pasture.

PASTURE				MET & REPR															
Chapter of the scient. report	Hazard identification			Hazard characterization							Exposure assessment						Risk Characterization		
	Hazard Nr.	Hazard description	Hazard specification	Adverse effect	Severity of the adverse effect	Duration of the adverse effect	Likelihood of the adverse effect			Uncertainty	Duration of the hazard	Intensity	Likelihood of the exposure to the hazard			Uncertainty	Risk estimate	Magnitude of adverse effect	Qualtitative uncertainty
							min	ml	max				min	ml	max				
MANAGEMENT																			
13.1	6	**Insufficient or inappropriate contact with humans**	neglect, lack of knowledge or lack of time	fear, injuries, reproductive and other disorders	1	1	5	10	15	H	180	few or no positive contact	10	15	20	H	0.00375	0.25	H
14	7	**Insufficient or inappropriate care of animals by stockperson**	neglect, lack of knowledge or lack of time	disease, prolonged disease, delayed treatment of disease	2	7	5	10	15	H	180	full exposure	20	30	40	H	0.105	3.5	H
12.3/11.2	8	**Inadequate preventive medicine, herd-health management including health recording**	neglect, lack of knowledge or lack of time	prolonged metabolic disease, delayed treatment of disease, dystocia, reproductive failure	1	10	20	30	40	M	180	full exposure	30	45	60	H	0.3375	2.5	H
12.3	9	**Inappropriate hormonal interventions on groups of animals**	mismatch physiological condition with the treatment	risk of improper treatment, induced abortion, metabolic stress	2	15	20	30	40	H	80	full exposure	2	5	8	H	0.1125	7.5	H
12.3	10	**Inadequate biosecurity**	introducing infectious/diseased cattle (without quarantine and testing) e.g. BVD, Johnes Disease, Leptospira	uterus infection, reproductive failure, abortion, metabolic stress due to disease	3	30	20	30	40	H	5	full exposure	50	70	90	H	4.725	22.5	H
12.3	11	**Inadequate biosecurity**	inadequate control of pest and vectors	uterus infection, reproductive failure, abortion, metabolic stress due to disease	3	30	5	10	15	H	100	full exposure	15	25	35	H	0.5625	22.5	H

Figure 29. Risk assessment hazards related to management in dairy cows kept in pasture (continued).

PASTURE				MET & REPR															
	Hazard identification			Hazard characterization							Exposure assessment						Risk Characterization		
Chapter of the scient. report	Hazard Nr.	Hazard description	Hazard specification	Adverse effect	Severity of the adverse effect	Duration of the adverse effect	Likelihood of the adverse effect			Uncertainty	Duration of the hazard	Intensity	Likelihood of the exposure to the hazard			Uncertainty	Risk estimate	Magnitude of adverse effect	Qualtitative uncertainty
							min	ml	max				min	ml	max				
	MANAGEMENT																		
12.3/11.2	12	**Witholding necessary veterinary therapeutic health care**		including unnecessarily metabolic and reproductive disease, uterus disease, including unnecessarily prolonged disease, early culling	2	15	30	40	50	H	30	full exposure	20	30	40	H	0.9	7.5	H
13.8	13	**Improper operational pain management**	Any surgery (e.g. caesarean, displaced abomasum, obstetric interventions, including foetotomy)	reduced DMI, metabolic disease, reduced fertility	3	5	60	70	80	M	10	full exposure	50	60	70	H	1.575	3.75	H
13.5	14	**Improper obstetric interventions**		uterus infection, metabolic diseases, reduced fertility, culling, death	3	10	60	70	80	M	21	full exposure	10	20	30	H	1.05	7.5	H
13.5	15	**Difficult calving because of the sire**	Dystocia	uterus infection, reduced DMI, metabolic disease, perinatal mortality, culling	2	14	60	70	80	M	1	full exposure	5	10	15	H	0.49	7	H
13.7	16	**Downer cow**	Improper management of downer cows - Lack of: physiotherapy, good bedding, proper facilities and lifting devices	metabolic diseases, culling, death	4	5	98	99	100	L	15	full exposure	0.5	1	1.5	M	0.0495	5	M

Figure 29. Risk assessment hazards related to management in dairy cows kept in pasture (continued).

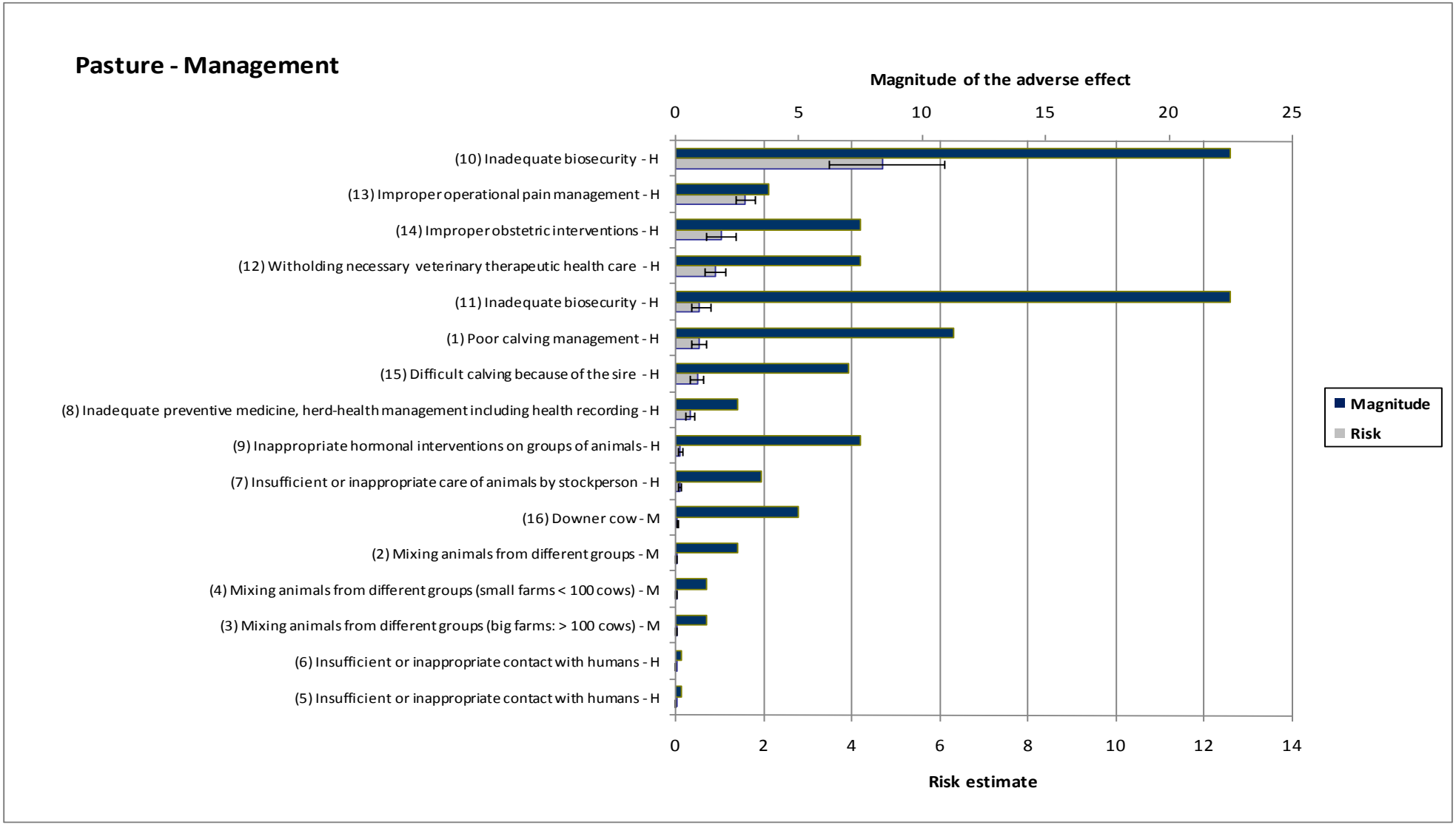

Figure 30. Ranking of hazards related to management in dairy cows kept in pasture.

PASTURE	MET & REPR																			
Chapter of the scient. report	Hazard identification			Hazard characterization							Exposure assessment							Risk Characterization		
	Hazard Nr.	Hazard description	Hazard specification	Adverse effect	Severity of the adverse effect	Duration of the adverse effect	Likelihood of the adverse effect			Uncertainty	Duration of the hazard	Intensity	Likelihood of the exposure to the hazard			Uncertainty	Risk estimate	Magnitude of adverse effect	Qualtitative uncertainty
							min	ml	max				min	ml	max				
GENETICS																			
4.2	**1**	**high genetic potential for production due to selection ignoring other traits**	with good housing, nutrition and management	reproductive disorders	2	50	35	50	65	L	180	estimated breeding value for yield in top quartile for breed and country	30	40	50	M	5	25	M
4.2	**2**	**high genetic potential for production due to selection ignoring other traits**	without good housing, nutrition and management	reproductive disorders	3	70	50	70	90	M	180	estimated breeding value for yield in top quartile for breed and country	40	50	60	M	18.375	52.5	M
4.2	**3**	**high genetic potential for production due to selection ignoring other traits**	with good housing, nutrition and management	metabolic disorders	2	70	35	50	65	L	180	estimated breeding value for yield in top quartile for breed and country	30	40	50	M	7	35	M
4.2	**4**	**high genetic potential for production due to selection ignoring other traits**	without good housing, nutrition and management	metabolic disorders	3	100	50	70	90	M	180	estimated breeding value for yield in top quartile for breed and country	40	50	60	M	26.25	75	M

Figure 31. Risk assessment hazards related to genetics in dairy cows kept in pasture.

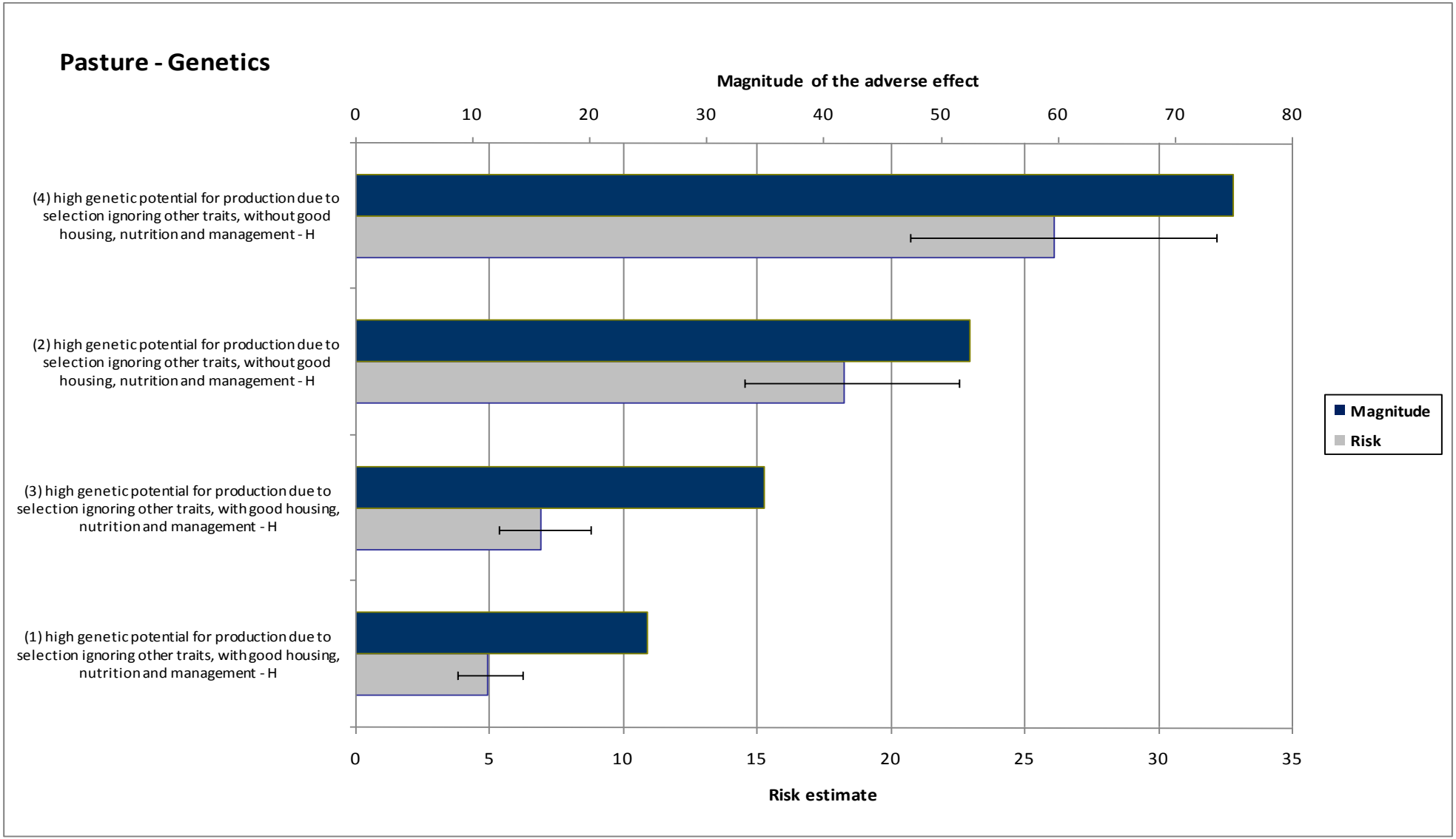

Figure 32. Ranking of hazards related to genetics in dairy cows kept in pasture.

GLOSSARY:

Dose-response Assessment

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

Exposure Assessment

The quantitative and qualitative evaluation of the likelihood of hazards to welfare occurring in a given dairy cow population.

Hazard

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

Hazard Identification

The identification of any factor, from birth to slaughter, capable of causing adverse effects on dairy cow welfare.

Magnitude of the adverse effect

The score resulting from the product of the severity and the duration of an adverse effect due to the hazard taken in consideration.

Risk

A function of the probability of an adverse effect and the severity of that effect, consequent to exposure to a hazard.

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 dairy cow population based on hazard identification, hazard characterisation, and exposure assessment.

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, nonetheless, 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

The output of risk characterisation. It results from the product of the hazard characterisation and exposure assessment scores.

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 or minimisation of risks), 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.