European Food Safety Authority

The EFSA Journal (2009) 1142, 1-57

Scientific opinion on welfare of dairy cows in relation to leg and locomotion 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-2008-337)

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, Mohan Raj, 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 leg and locomotion problems in dairy cows. *The EFSA Journal* (2009) 1142, 1-57

[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 the welfare of dairy cows in relation to leg and locomotion 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 is concluded that the farming system has a major influence on leg and locomotion problems defined both in terms of magnitude of the adverse effect and risk estimate. Hazards associated with housing and management rank much higher, in terms of risk estimate, than those associated with nutrition and genetics. Magnitudes of the adverse effects and risk estimates in housing are much greater in systems involving cubicle housing or tie-stalls, than in straw yards or at pasture. Hazards attributable to management and genetic selection for high yields are similar for all farming systems, however risk estimates are higher in cubicles and tie-stalls than in straw yards or at pasture. In general, concrete flooring has a higher risk of claw disorders than pasture and straw-yards, since standing and walking for prolonged periods on concrete floors, or floors that are wet or covered in slurry cause severe foot disorders.

According to the scoring system used in this analysis, the most important hazard in relation to the housing was the lack of space in tie-stalls. Larger space allowance, in the walking area as well as the lying area, is beneficial for the welfare of cows with respect to decreased aggression, injuries, and occurrence of lameness. Tied cattle have more lameness than those free to move with good flooring and resting facilities. In cubicles the most important magnitudes of the adverse effect and risk estimates are associated with inadequate floor in the walking area, poor cubicle design and inadequate bedding. Dairy cows have a strong motivation for lying, and lie down for 7-15 hours per day. The lying time varies between housing systems and can be affected by housing design. Altered patterns of lying down can be a sign of lameness, injury or poor housing design. When dairy cattle are kept in cubicle houses, foot and leg disorders are substantially more frequent than they are in straw yards. Since leg and foot disorders are the major welfare problem for dairy cattle and leg and foot disorders are a problem even in well-managed cubicle houses, alternatives to cubicles, e.g. straw yards, are needed and in the short-term improvements to cubicle house design should be made.

In the case of nutrition and feeding the most important hazards are inadequacies in transition feeding and imbalanced diets. The greatest risk estimate is related to transition feeding. However the probability of risks attributable to nutrition and feeding systems are low relative to those attributable to housing and management.

As regards the management measures for dairy cows, the risk assessment showed that the most important management hazards causing leg and locomotion problems are those related to inadequate care and monitoring of foot health and hygiene, and these are similar across all housing systems considered. However the risk estimate and magnitude of the adverse effect are exacerbated by hazards in the housing category and are approximately twice as great in cubicle systems and tie-stalls as in straw yards or at pasture. Most lame cows are in pain and have greater difficulty in coping with their living conditions than non-lame cows because of the effects of the foot or leg disorder on walking, lying comfort, standing up and avoidance

behaviour. Lame cows are more likely to become subordinate, lose body condition and are more prone to show reduced fertility and to develop mastitis and metabolic disease. Weekly attention to foot hygiene in dairy cattle leads to reduction of infectious conditions of the foot. When the prevalence of recognisable locomotor difficulties in dairy cattle is above 10%, this indicates that the prevention programme is inadequate. Because of the high risk of lameness in dairy cattle all dairy farmers should implement a lameness prevention programme. Well-executed hoof-trimming can reduce the likelihood of lameness and improve cow welfare but poorly executed hoof-trimming can cause lameness.

The genetic selection has changed the form and size of dairy cows and hence demands on their behaviour and other adaptive mechanisms. The spatial requirements of the dairy cow have increased, as well as its vulnerability for mechanical impacts and wounds on the exterior parts of the body, the skin, limbs and claws. Udder shape and volume are of specific concern, with respect to normal locomotion, prevention of lameness and comfort during resting in the most common housing types. The risk assessment confirmed that genetic selection for high milk yield with insufficient emphasis on other traits relating to fitness increases the risk of suffering from leg and locomotion problems. This risk is greater when housing, nutrition and management are unable to compensate for the adverse effects of genetic selection.

A general conclusion is that leg and locomotion problems in dairy cows are multifactorial in origin, so that the magnitudes of the adverse effect in individual animals and the risk estimates, measured in terms of herd prevalence, can usually be attributed to a combination of hazards associated with housing, feeding and nutrition, management and genetics. However the most important hazards and risks are those associated with inadequate provisions for lying, standing and walking in cubicle houses and tie-stalls, and management failures relating to locomotion monitoring and foot care.

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

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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 base 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 leg and locomotion problems in dairy cows.

ACKNOWLEDGEMENTS

The European Food Safety Authority and the AHAW Panel wish to thank the following members of the Working Group: Donald Broom, Jörg Hartung, Lena Lidfors, George Stilwell, Frans Smulders, Telmo Nunes, Pascal Oltenacu, John Webster and Elsbeth Stassen, 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 Ribó.

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 include 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 performance criteria.

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 in 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, therefore 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 of 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 asses 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

a) 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.

b) Any difference in the Exposure Assessment between the tables in the different scientific opinions is related to the different hazard specifications.

c) Running numbers in the first column of the Tables cross reference the hazards in the chart.

d) 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.

e) 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.

f) 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

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.

It was concluded from the Scientific Report that leg and locomotion problems in dairy cows are multifactorial in origin, so that the magnitude of the adverse effect in individual animals and the risk estimates, measured in terms of herd prevalence can usually be attributed to a combination of hazards associated with housing, feeding management and genetics. The risk assessment led to the conclusion that the most important hazards and risks are those associated with inadequate provisions for lying, standing and walking in cubicle houses and tie-stalls, and inadequate locomotion monitoring and foot care due to poor herd management and stockmanship.

General conclusions from the risk assessment

Hazards associated with housing and management have been evaluated in the Risk Assessment and conclusions drawn up, as follows:

- Hazards associated with housing and management ranked much higher than those associated with nutrition and genetics.
- Magnitudes of the adverse effects and risk estimates in housing were much greater in systems involving cubicle housing or tie-stalls, than in straw yards or at pasture.
- Risk estimates related to management and genetic selection were higher in cubicles and tie-stalls than in straw yards or at pasture.

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

4.2.1 Lameness and other production diseases

Conclusions

- The genetic selection has changed the form and size of dairy cows and hence demands on their behaviour and other adaptative mechanisms. The spatial requirements of the dairy cow have increased as well as its vulnerability for mechanical impacts and wounds on the exterior parts of the body, the skin, limbs and claws.
- Udder shape and volume are of specific concern, with respect to normal locomotion, prevention of lameness and comfort during resting in the most common housing types.
- The genetic component underlying milk yield has been found to be positively correlated with the incidence of lameness, mastitis, reproductive disorders and metabolic disorders. These changes and others that result from genetic selection have increased the size of dairy cattle, made their management more difficult.
- The **risk assessment** showed that genetic selection for high milk yield with insufficient emphasis on other traits relating to fitness increases the risk of suffering leg and locomotion problems. This risk is greater when housing, nutrition and management are unable to compensate for the adverse effects of genetic selection.

Recommendations

- In order to improve dairy cow welfare there is an urgent need to promote changes in the criteria used for genetic selection in the dairy industry. These changes should result in animals in which there are fewer demands on their mechanism of adaptability, less lameness, less mastitis, less reproductive disorder and less metabolic disorder.
- Breeding objectives should include resistance to mastitis, lameness and other diseases.

Chapter 5 – Nutrition

- The **risk assessment** showed that the most important hazards of leg and locomotion disorders associated with nutrition and feeding systems are inadequacies in transition feeding and imbalanced diets.
- The **risk assessment** showed that the greatest risk estimate is related to transition feeding. However the probability of risks attributable to nutrition and feeding systems are low relative to those attributable to housing and management.

Chapter 6 - Housing conditions in relation to welfare

Conclusions

- The result of the evaluation of the leg and locomotion disorders made in the **risk assessment** was that hazards related to the housing conditions have a major influence on leg and locomotion problems defined both in terms of the magnitude of the adverse effect and the risk estimate, compared with the rest of the hazard categories.

6.1.4 Walking areas

Conclusions

- When there is not a cubicle for every cow in a cubicle house, reduced lying time and aggression with associated poor welfare are more likely to occur. It may also lead to increased lameness and mastitis.
- The **risk assessment** showed that in cubicles the greatest magnitudes of the adverse effects and risk estimates are associated with inadequate floor in the walking area, poor cubicle design and inadequate bedding.

Recommendations

- In cubicle houses there should be at least as many cubicles as there are cows in the house.
- In cubicle houses, injuries to the cows should be monitored and the cubicles modified or replaced, if repeated injuries occur because of poor design.

6.2 Space allowance

Conclusions

- Having a choice, cows would choose more individual space than is available in most housing systems. Larger space allowance, in the walking area as well as the lying area, is beneficial for the welfare of cows and heifers with respect to decreased aggression, injuries, and occurrence of lameness. Understocking has positive effects on the welfare.

6.6 Resting

Conclusions

- Leg and foot disorders are the major welfare problem for dairy cattle, in terms of incidence and magnitude of adverse effect. Leg and foot disorders are a problem even in well managed cubicle houses.
- Dairy cows have a strong motivation for lying, and lie down for 7-15 hours per day. The lying time varies between housing systems and can be affected by housing design. Altered patterns of lying down can be a sign of lameness, injury or poor housing design.
- When dairy cattle are kept in cubicle houses, foot and leg disorders are substantially more frequent than they are in straw yards.
- In the **risk assessment** and according to the scoring system used in this analysis, the most important magnitudes of the adverse effect and risk estimates in housing are approximately 10 times greater in cubicle houses and tie-stalls than in straw yards or at pasture.

Recommendations

- Since leg and foot disorders are the major welfare problem for dairy cattle and leg and foot disorders are a problem even in well managed cubicle houses, alternatives to cubicles e.g. straw yards and improvements to cubicle house design should be considered.

6.8.5 Effects of housing on locomotion and exercise

Conclusions

- Knowledge of the locomotor activity is of help in identifying when the flooring or housing design is causing problems for the cows. Cows walk 2-4 km/day when they can do so but if the floor is slippery, the building is poorly lit or there is too little space they may walk much less.
- Tied cows are unable to walk. Exercise of tied dairy cows may have positive effects on their health and helps the farmer to detect oestrus, as well as improving cow welfare.
- Dairy cattle are motivated to walk independently of the need to feed or drink. For animals free to move, exercise has benefits and no disadvantages unless the cattle are forced to walk too fast (> 5 km/hour) or too far (for example, in one publication 9.6 km/day).
- Dairy cattle are reluctant to be tied, both initially and after a period of exercise and tied cattle have more lameness than those free to move with good flooring and resting facilities.
- In the **risk assessment** the highest ranked hazard was lack of space in tie-stalls.

6.8.6 to 6.8.9 Dairy cows and pasture

Conclusions

- If dairy cows are not kept on pasture for parts of the year, i.e. they are permanently on a zero-grazing system, there is an increased risk of lameness, hoof problems, teat tramp, mastitis, metritis, dystocia, ketosis, retained placenta and some bacterial infections.
- Standing and walking for prolonged periods on concrete floors, or floors that are wet or covered in slurry cause severe foot disorders. Concrete flooring has a higher risk of claw disorders than pasture and straw-yards.

Recommendations

- Dairy cattle should not be caused to stand or walk for prolonged periods on concrete floors or floors that are wet or covered in slurry.

Chapter 7 - Milking procedures in relation to welfare

7.3.2. Milking process

Conclusions

Long waiting times before milking can lead to dairy cows having insufficient time for eating and resting, it may also increase the risk of foot lameness.

Chapter 8 - Social and maternal behaviour in relation to management and welfare

8.1.3 Affiliate relationships and welfare

Conclusions

- Grouping and re-grouping of cows often cause increased aggression and can cause lameness, resulting in poor welfare and impaired production.

Chapter 9 - Lameness and welfare

9.2 Incidence and prevalence

Conclusions

- Lameness is mainly a consequence of foot disorders.
- Despite research and increasing awareness of lameness in relation to welfare and lost productivity, there has been no reduction in the prevalence of lameness in the last 20 years.

9.3. Pathology, pathogenesis and treatment and 9.4 Assessment and monitoring of lameness

Conclusions

- A range of pathological conditions may lead to foot pain and lameness in dairy cows and these may be caused by factors such as genetic predisposition, pathogens, feeding regime, building design, flooring or poor hygiene and management.
- Locomotion and foot lesion scores can be used to monitor the prevalence and severity of lameness.
- Weekly attention to foot hygiene in dairy cattle leads to reduction of infectious conditions of the foot.
- A prevalence of lameness of up to 2% is achievable on commercial farms. When the prevalence of recognisable locomotor difficulties in dairy cattle approaches 10%, this indicates that the existing housing and management systems are inadequate.
- The **risk assessment** showed that the most important management hazards causing leg and locomotion problems are those related to inadequate care and monitoring of foot health and hygiene. However the risk estimate and magnitude of the adverse effects are exacerbated by housing hazards and approximately twice as great in cubicle systems and tie-stalls as in straw yards or at pasture.

Recommendations

- There should be systems for monitoring the prevalence and severity of lameness by scoring locomotion and foot lesions every 3 to 6 months in all dairy herds.
- Foot inspection with trimming as necessary should be carried out at intervals not greater than 6 months.
- There should be attention to foot hygiene of dairy cattle on a weekly basis, followed by proper treatment as necessary.
- Because of the high risk of lameness in dairy cattle all dairy farmers should implement a lameness prevention programme.
- Lameness should be prevented although in practice this can rarely be achieved at present. Clinical cases should be given proper veterinary care. When systematic monitoring indicates an increasing prevalence, appropriate corrective measures should be taken at herd level. On farms with a high prevalence of recognisable locomotor difficulties, e.g. approaching 10%, there should be improvement of housing conditions, genetic strain and management practices.

Recommendations for future research

- Develop automated systems for monitoring locomotion and the prevalence and severity of lameness.

9.5 Lameness and Animal Welfare

Conclusions

- Most lame cows are in pain and have greater difficulty in coping with their living conditions than non-lame cows because of the effects of the foot or leg disorder on walking, lying comfort, standing up and avoidance behaviour.
- Lame cows are more likely to become subordinate, lose body condition and are more prone to show reduced fertility and to develop mastitis and metabolic disease.
- Well-executed hoof-trimming can reduce the likelihood of lameness and improve cow welfare but poorly executed hoof-trimming can cause lameness.

Recommendations

- Pain relief should be provided during and after treatment for severe lameness.
- Hoof-trimming should be carried out with care by professionally trained and certified personnel.

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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				LEG & LOCOMOTION DISORDERS															
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																			
5.1 / 6.1	1	**Inadequate feeding installation**	incorrect positioning or design	leg injuries, claw disorders, pain	3	60	5	10	15	M	365	full exposure	10	20	30	M	0.9	45	M
6.1	2	**Poor cubicle design**	--	leg injuries, claw disorders, pain	4	60	50	60	70	L	365	full exposure	40	70	90	L	25.2	60	L
6.7	3	**Inadequate bedding**	hygiene, composition and quantity	leg injuries, claw disorders, pain	4	60	50	60	70	L	365	full exposure	30	50	70	M	18	60	M
6.1	4	**Inadequate floor in area where cows walk**	too slippery, too hard, injuring, too rough	leg injuries, claw disorders, pain	4	60	50	60	70	L	365	full exposure	50	70	100	M	25.2	60	M
6.2	5	**Lack of space, e.g. for exercising, social interactions and resting**	--	locomotion disorders	2	40	0	1	2	H	365	full exposure	40	60	80	H	0.12	20	H
12.3	6	**Lack of facilities for sick / injured animals**	hospital pens	poor recovery, pain	4	60	15	20	25	M	365	full exposure	50	70	90	H	8.4	60	H
12.3	7	**Lack of facilities for sick / injured animals**	foot baths	disease transmission (e.g. digital dermatitis)	3	60	50	60	70	M	365	full exposure	20	25	30	H	6.75	45	H

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

CUBICLE HOUSES				LEG & LOCOMOTION DISORDERS															
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																			
6.2	**8**	**Fewer cubicles than cows**	with access to pasture	leg injuries, claw disorders, pain	4	60	50	60	70	L	180	full exposure	1	2	3	H	0.72	60	H
6.2	**9**	**Fewer cubicles than cows**	zero-grazing	leg injuries, claw disorders, pain	4	60	60	70	80	L	365	>10% overstocking	1	2	3	H	0.84	60	H
13.1	**10**	**Inadequate or lack of handling/restraining facilities**	temporary facilities taken into account (e.g. foot trimmer provides)	leg injuries, claw disorders, pain	4	60	5	10	15	L	10	full exposure	30	50	70	H	3	60	H
6.9	**11**	**Poor maintenance of flooring (zero-grazing animals)***	repair, manure, floor hygiene	leg injuries, claw disorders, pain	4	60	50	60	70	L	365	full exposure	15	30	50	H	10.8	60	H
6.1	**12**	**Inadequate design of waiting area**	size, flooring, crowding gates	leg injuries, claw disorders, pain	4	60	5	10	15	M	325	full exposure	15	30	45	H	1.8	60	H
6.1	**13**	**too few feeding places in zero grazing systems**	--	leg injuries, claw disorders, pain	3	40	10	15	20	M	365	> 1 cow per place	5	10	15	H	0.45	30	H
6.1	**14**	**too few feeding places (cows with access to pasture)**	--	leg injuries, claw disorders, pain	3	40	5	10	15	M	215	> 1 cow per place	10	20	30	H	0.6	30	H

Figure 2. Risk assessment: hazards related to housing in dairy cows kept in cubicle houses (continued).

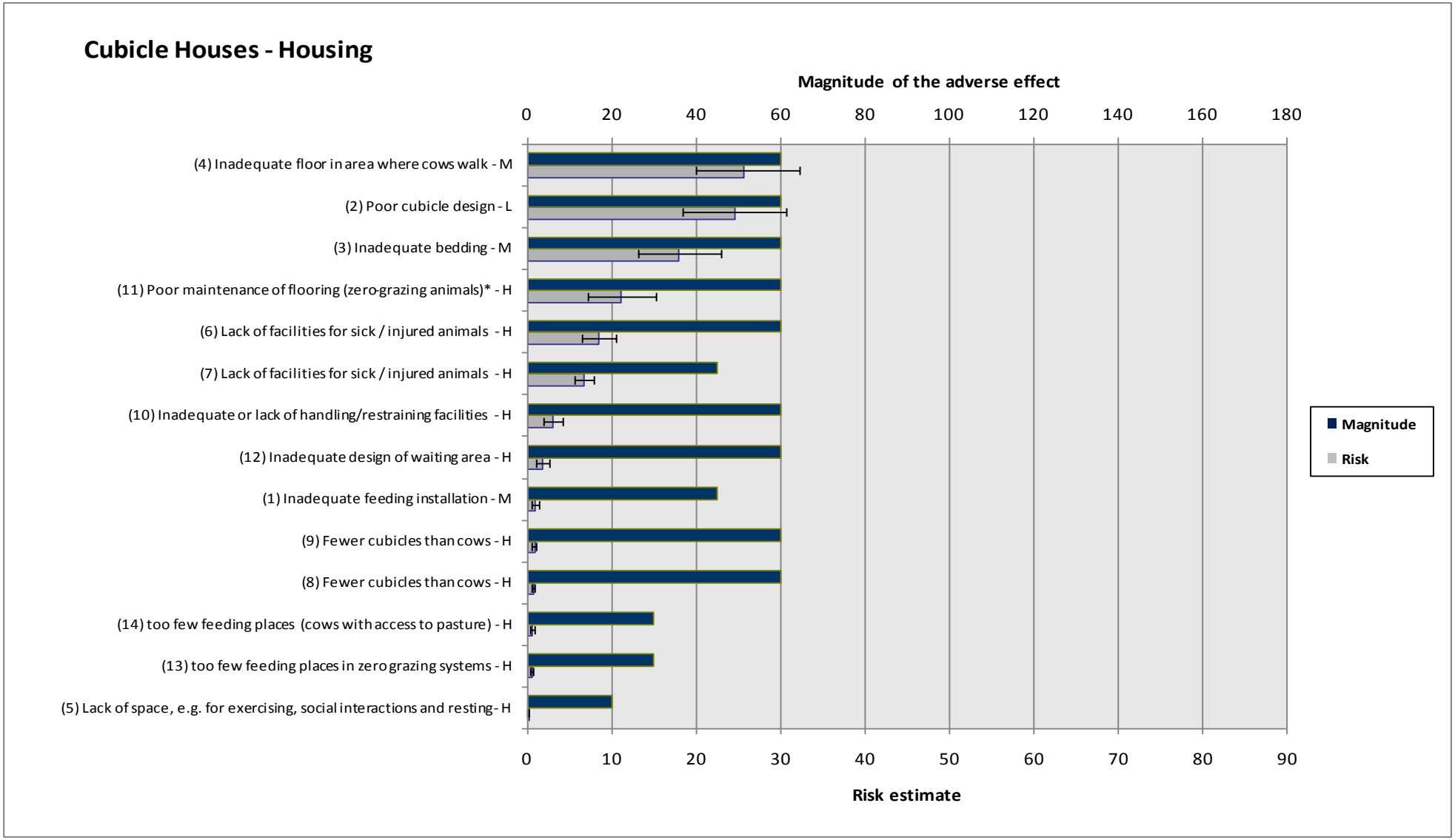

Figure 3. Ranking of hazards related to housing in dairy cows kept in cubicle houses.

CUBICLE HOUSES				LEG & LOCOMOTION DISORDERS																
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				
NUTRITION AND FEEDING																			
5.1	1	**Poor feed quality (roughage)**	wet silage	infectious foot disorders, pain	3	10	10	20	30	M	100	< 25 % DM	20	30	40	H	0.45	7.5	H
5.1	2	**Improper ration composition**	Inadequate fibre/carbohydrate ratio (< 40 %) and fibre quality/length	claw disorders, laminitis, pain	4	60	10	15	20	L	325	rumen pH < 5.8 more than 3 hours	15	20	25	H	1.8	60	H
5.1	3	**Inadequate transition feeding**	Inadequate feeding strategy, energy and fibre supply	claw disorders, laminitis, pain	4	60	5	10	15	M	45	See S. Report Chapter 10	30	50	70	M	3	60	M
5.1	4	**Overfeeding**	excess of nutrient supply in relation to genotype and energy output at the end of lactation and dry period	claw disorders, laminitis, pain	4	60	1	5	10	M	100	BCS > 3.75	15	20	25	M	0.6	60	M

Figure 4. Risk assessment: hazards related to nutrition and feeding in dairy cows kept in cubicle houses.

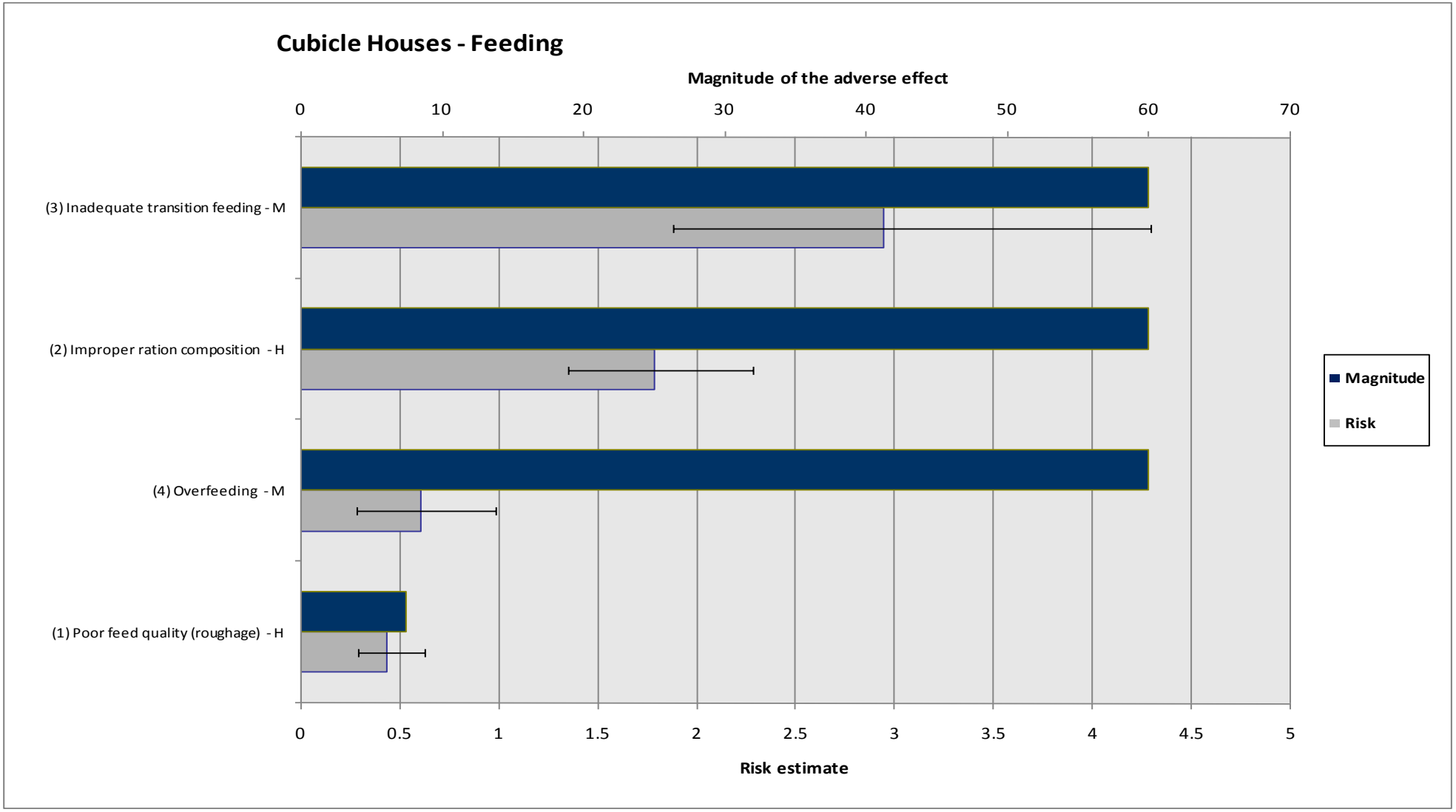

Figure 5. Ranking of hazards related to nutrition and feeding in dairy cows kept in cubicle houses.

CUBICLE HOUSES				LEG & LOCOMOTION DISORDERS																
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				
MANAGEMENT																			
8.1	1	**Mixing animals from different groups**	the single animal is moved to another group	foot injuries, infectious foot disorders, pain	3	30	5	10	15	M	5	full exposure	98	99	100	M	2.2275	22.5	M
14	2	**Insufficient or inappropriate care of animals by stockperson**	delayed detection of lameness due to negligence /lack of knowledge	foot injuries, infectious foot disorders, pain	4	60	70	80	90	L	365	full exposure	20	30	40	M	14.4	60	M
9.3 / 9.6	3	**Inadequate preventive medicine, herd-health management: infectious disease**	inadequate foot hygiene (e.g. foot bathing)	infectious foot disorders, pain	3	60	40	50	60	L	365	full exposure	40	60	80	H	13.5	45	H
12.3	4	**Inadeqate biosecurity**	introducing infections particularly to heifers e.g. by contaminated environment	infectious foot disorders (e.g. digital dermatitis), pain	3	60	50	60	70	M	5	full exposure	20	25	30	H	6.75	45	H
9.3 / 9.6	5	**Witholding necessary therapeutic health care**	failure to treat early lameness	claw disorders, infectious foot disorders, pain	4	60	70	80	90	L	40	full exposure	10	20	30	H	9.6	60	H

Figure 6. Risk assessment: hazards related to management in dairy cows kept in cubicle houses.

CUBICLE HOUSES		LEG & LOCOMOTION DISORDERS																	
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				
MANAGEMENT																			
9.3	**6**	**poor health care and welfare plan**	absence of preventive functional trimming	claw disorders, infectious foot disorders, pain	3	60	50	60	70	L	180	full exposure	50	60	70	H	16.2	45	H
9.3 /9.4 / 9.6	**7**	**Inadequate clinical health monitoring**	including recording and planning e.g. claw disease	claw disorders, infectious foot disorders, pain	3	60	10	20	30	M	365	full exposure	40	70	90	H	6.3	45	H
13.8	**8**	**Improper analgesia during procedure**	Treatment of claw lesions	pain	4	10	98	99	100	L	3	full exposure	15	20	25	M	1.98	10	M
13.7	**9**	**Downer cow**	Improper management of downer cows - Lack of: physiotherapy, good bedding, proper facilities and lifting devices	paralysis, pain	4	5	98	99	100	L	15	full exposure	0.5	1	1.5	M	0.0495	5	M

Figure 7. Risk assessment: hazards related to management in dairy cows kept in cubicle houses (continued).

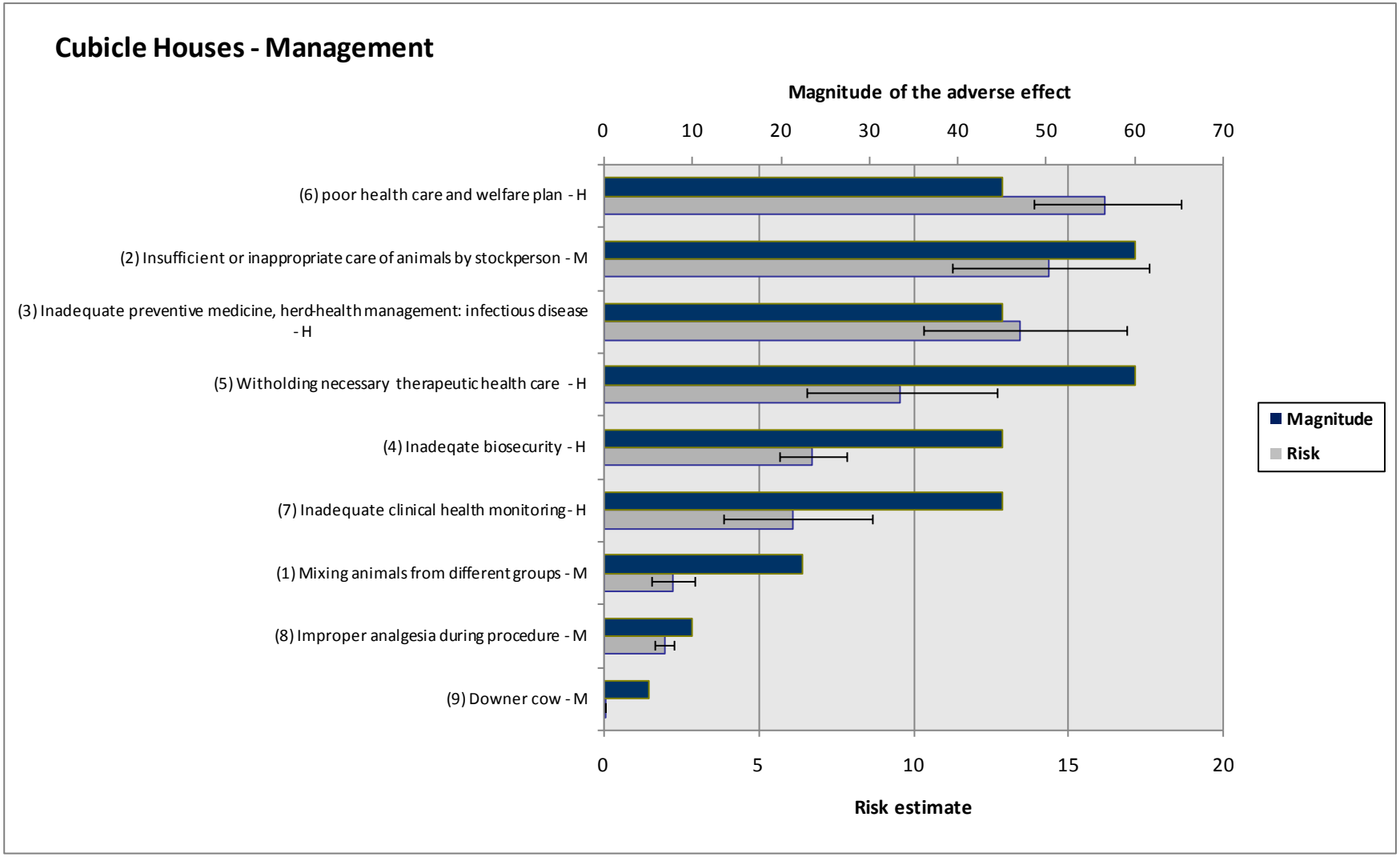

Figure 8. Ranking of hazards related to management in dairy cows kept in cubicle houses.

CUBICLE HOUSES				LEG & LOCOMOTION DISORDERS																
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				
GENETICS																			
4.2	1	**high genetic potential for production due to selection ignoring other traits**	with good housing, nutrition and management	leg injuries, claw disorders, pain	3	40	50	60	70	L	365	estimated breeding value for yield in top quartile for breed and country	20	30	40	M	5.4	30	M
4.2	2	**high genetic potential for production due to selection ignoring other traits**	without good housing, nutrition and management	leg injuries, claw disorders, pain	3	60	70	80	90	M	365	estimated breeding value for yield in top quartile for breed and country	30	40	50	M	14.4	45	M

Figure 9. Risk assessment hazards related to genetics in dairy cows kept in cubicle houses.

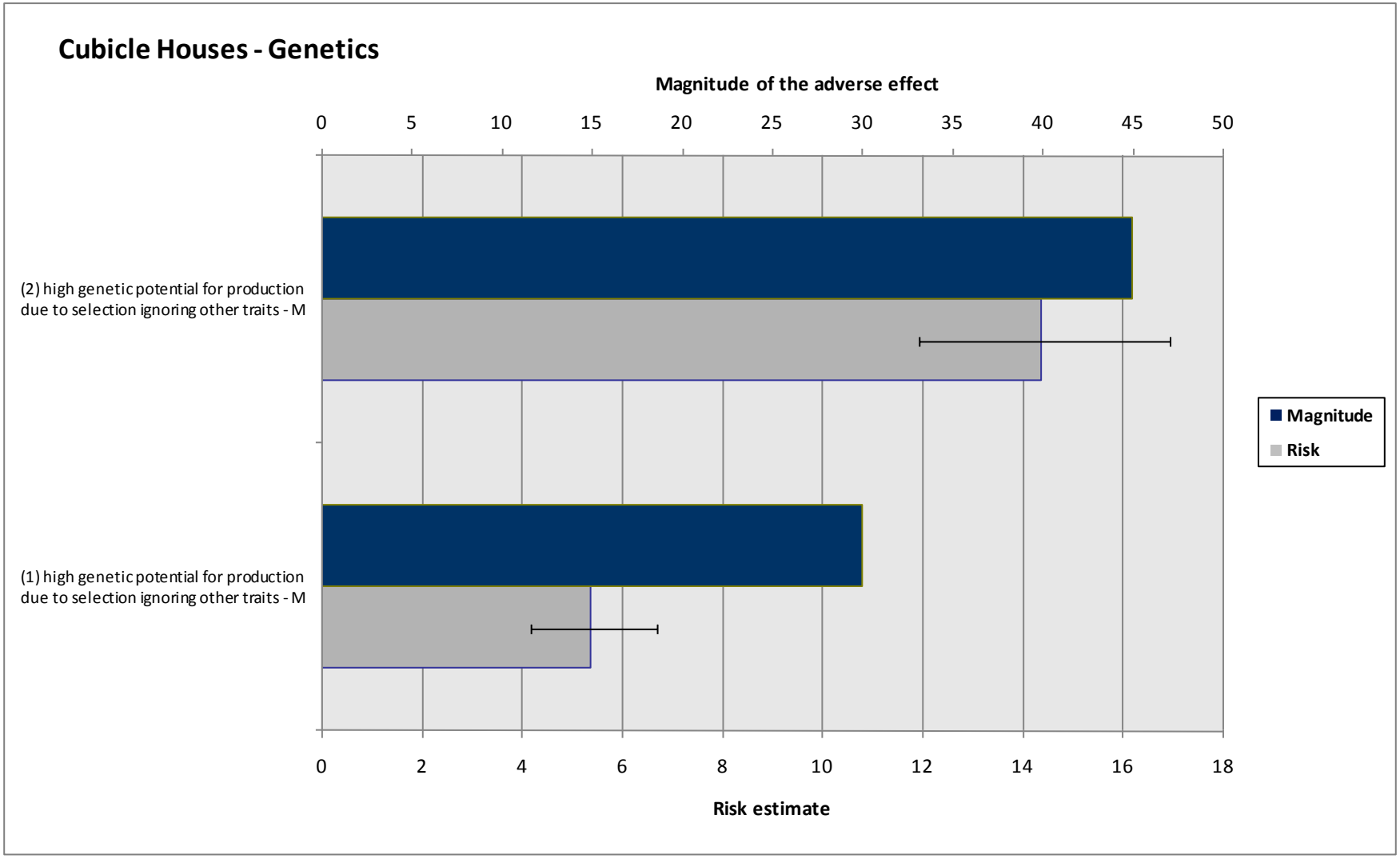

Figure 10. Ranking of hazards related to genetics in dairy cows kept in cubicle houses.

TIE-STALLS				LEG & LOCOMOTION DISORDERS																
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																			
5.1 / 6.1	1	**incorrect positioning or design of feeding installation**	--	leg injuries, claw disorders pain	3	60	5	10	15	H	365	full exposure	0.1	0.2	0.3	M	0.009	45	H
6.1	2	**Poor stall design**	--	leg injuries, claw disorders pain	3	60	10	15	20	M	365	full exposure	40	70	90	L	4.725	45	M
6.7	3	**Inadequate bedding**	hygiene, composition and quantity	leg injuries, claw disorders pain	3	60	20	30	40	M	365	full exposure	30	50	70	M	6.75	45	M
6.1	4	**Inadequate floor in area where cows walk**	too slippery, too hard, injuring, too rough	leg injuries, claw disorders pain	3	60	5	10	15	M	365	full exposure	5	10	15	M	0.45	45	M
6.2	5	**Lack of space for exercising**	--	locomotion disorders	2	325	40	50	60	M	365	full exposure	85	90	95	H	73.125	162.5	H
12.3	6	**Lack of facilities for sick / injured animals**	hospital pens	poor recovery, pain	3	60	15	20	25	M	365	full exposure	50	70	90	H	6.3	45	H
13.1	7	**Inadequate or lack of handling/restraining facilities**	--	leg injuries, claw disorders, pain	4	60	10	15	20	L	10	full exposure	30	50	70	H	4.5	60	H
6.9	8	**Poor maintenance of flooring ***	repair, manure, floor hygiene	leg injuries, claw disorders, pain	3	60	5	10	15	M	365	full exposure	5	10	15	M	0.45	45	M

Figure 11. Risk assessment hazards related to housing in dairy cows kept in tie-stalls.

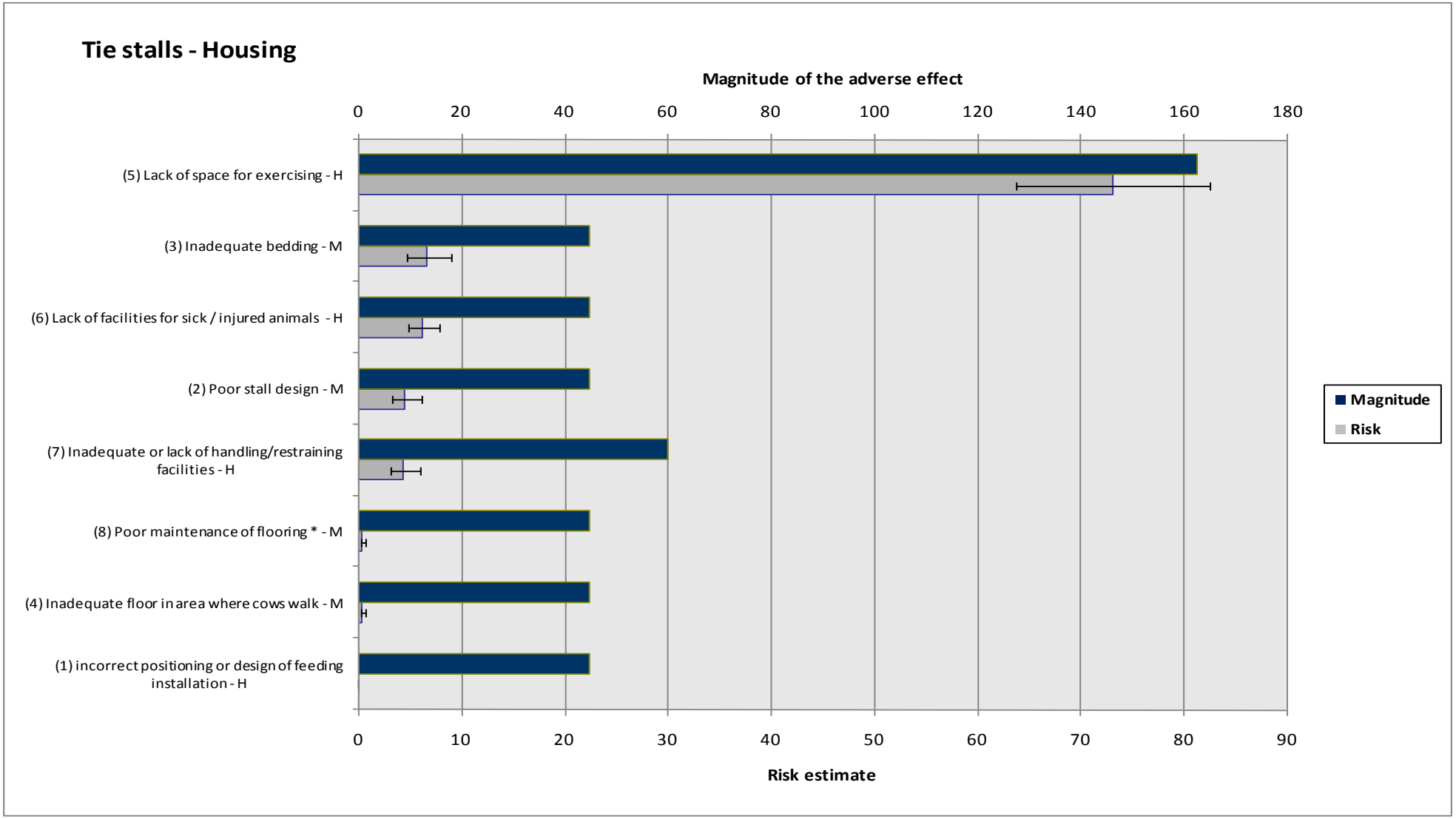

Figure 12. Ranking of hazards related to housing in dairy cows kept in tie-stalls.

TIE-STALLS				LEG & LOCOMOTION DISORDERS															
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				
NUTRITION AND FEEDING																			
6.1	1	**Poor feed quality (roughage)**	wet silage	foot disorders, pain	3	10	10	20	30	M	100	< 25 % DM	20	30	40	H	0.45	7.5	H
6.1	2	**Improper ration composition**	Inadequate fibre/carbohydrate ratio (< 40 %) and fibre quality/length	claw disorders, laminitis, pain	4	60	10	15	20	L	325	rumen pH < 5.8 more than 3 hours	15	20	25	H	1.8	60	H
6.1	3	**Inadequate transition feeding**	Inadequate feeding strategy, energy and fibre supply	claw disorders, laminitis, pain	4	60	5	10	15	M	45	See S. Report Chapter 10	30	50	70	M	3	60	M
6.1	4	**Overfeeding**	excess of nutrient supply in relation to genotype and energy output at the end of lactation and dry period	claw disorders, laminitis, pain	4	60	1	5	10	M	100	BCS > 3.75	15	20	25	M	0.6	60	M

Figure 13. Risk assessment hazards related to nutrition and feeding in dairy cows kept in tie-stalls.

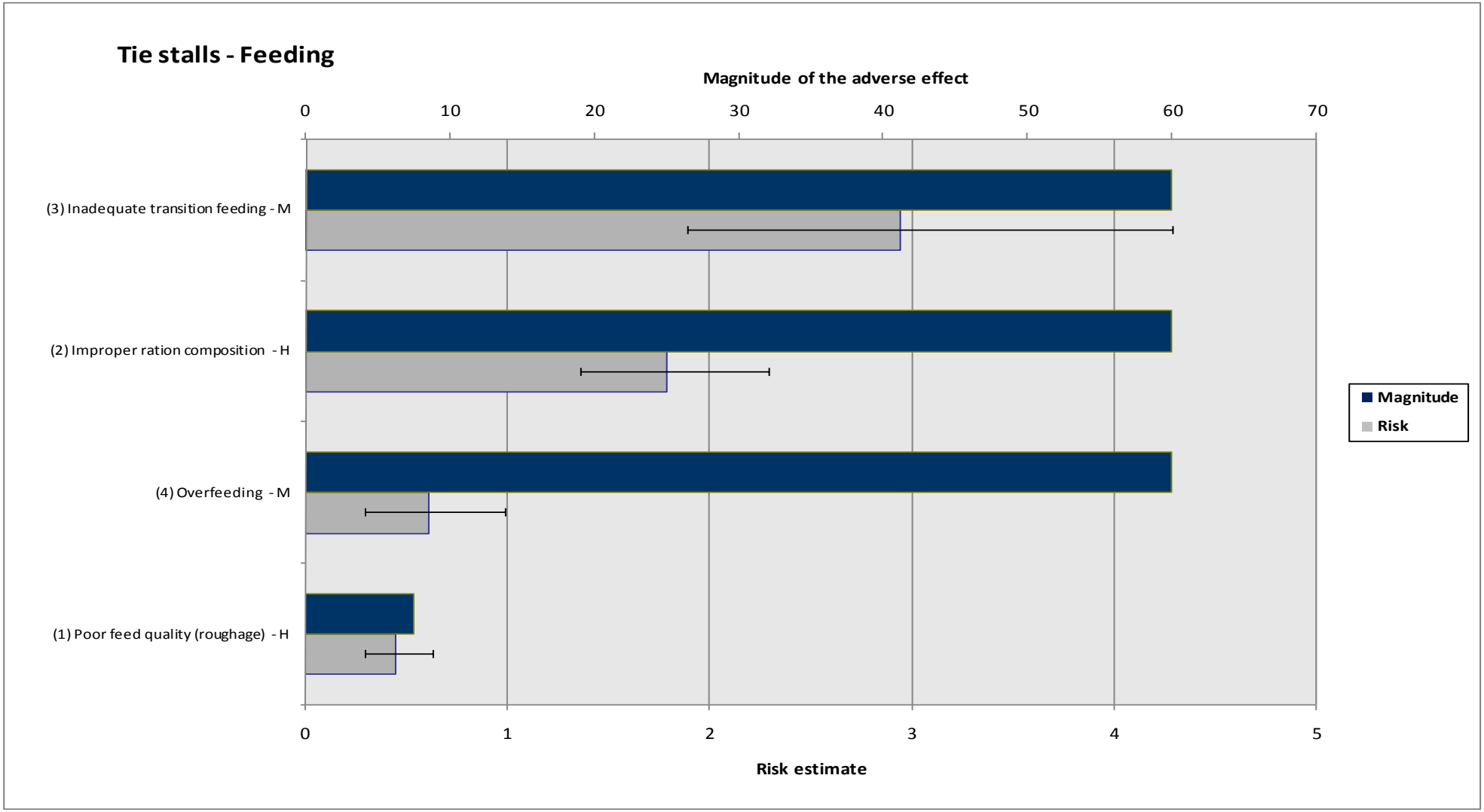

Figure 14. Ranking of hazards related to nutrition and feeding in dairy cows kept in tie-stalls.

TIE-STALLS				LEG & LOCOMOTION DISORDERS																
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				
MANAGEMENT																			
14	1	**Insufficient or inappropriate care of animals by stockperson**	delayed detection of lameness due to negligence /lack of knowledge	foot injuries, infectious foot disorders, pain	4	60	70	80	90	L	365	full exposure	20	30	40	M	14.4	60	M
9.3/ 9.6	2	**Inadequate preventive medicine, herd-health management: infectious disease**	inadequate foot hygiene (e.g. foot bathing)	infectious foot disorders, pain	3	60	5	10	15	L	365	full exposure	40	60	80	H	2.7	45	H
12.3	3	**Inadeqate biosecurity**	introducing infections particularly to heifers e.g. by contaminated environment	infectious foot disorders (e.g. digital dermatitis), pain	3	60	5	10	15	M	5	full exposure	20	25	30	H	1.125	45	H
9.3/ 9.6	4	**Witholding necessary therapeutic health care**	failure to treat early lameness	claw disorders, infectious foot disorders, pain	4	60	70	80	90	L	40	full exposure	10	20	30	H	9.6	60	H
9.3	5	**poor health care and welfare plan**	absence of preventive functional trimming	claw disorders, infectious foot disorders, pain	3	60	50	60	70	L	180	full exposure	50	60	70	H	16.2	45	H
9.3/9.4 / 9.6	6	**Inadequate clinical health monitoring**	including recording and planning e.g. claw disease	claw disorders, infectious foot disorders, pain	3	60	10	20	30	M	365	full exposure	40	70	90	H	6.3	45	H
13.8	7	**Improper analgesia during procedure**	Treatment of claw lesions	pain	4	10	98	99	100	L	3	full exposure	15	20	25	M	1.98	10	M
13.7	8	**Downer cow**	Improper management of downer cows - Lack of: physiotherapy, good bedding, proper facilities and lifting devices	paralysis, pain	4	5	98	99	100	L	15	full exposure	0.5	1	1.5	M	0.0495	5	M

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

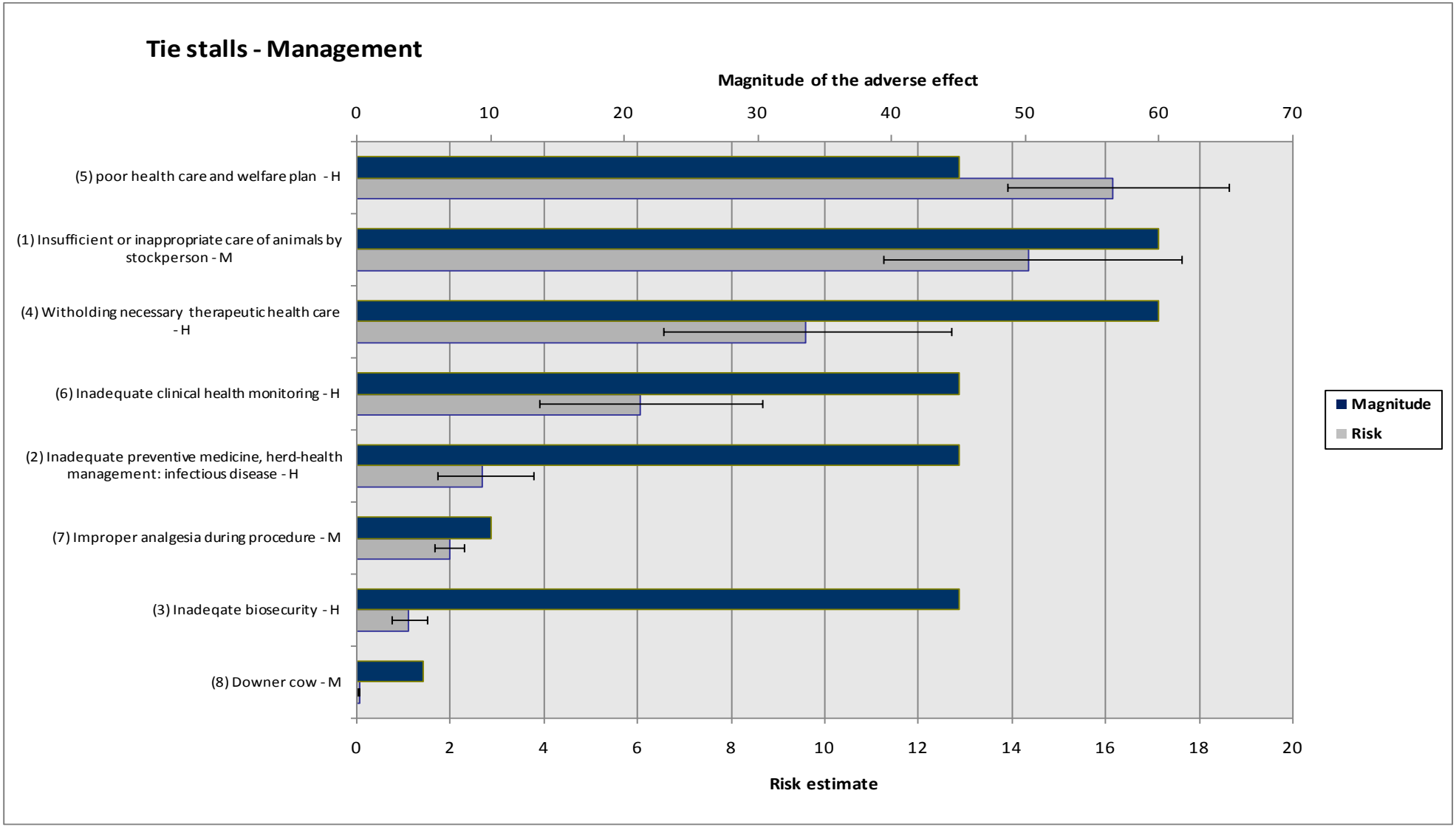

Figure 16. Ranking of hazards related to management in dairy cows kept in tie-stalls.

TIE-STALLS				LEG & LOCOMOTION DISORDERS																
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				
GENETICS																			
4.2	1	**high genetic potential for production due to selection ignoring other traits**	with good housing, nutrition and management	leg injuries, claw disorders, pain	3	40	40	50	60	L	365	estimated breeding value for yield in top quartile for breed and country	20	30	40	M	4.5	30	M
4.2	2	**high genetic potential for production due to selection ignoring other traits**	without good housing, nutrition and management	leg injuries, claw disorders, pain	3	60	70	80	90	M	365	estimated breeding value for yield in top quartile for breed and country	30	40	50	M	14.4	45	M

Figure 17. Risk assessment hazards related to genetics in dairy cows kept in tie-stalls.

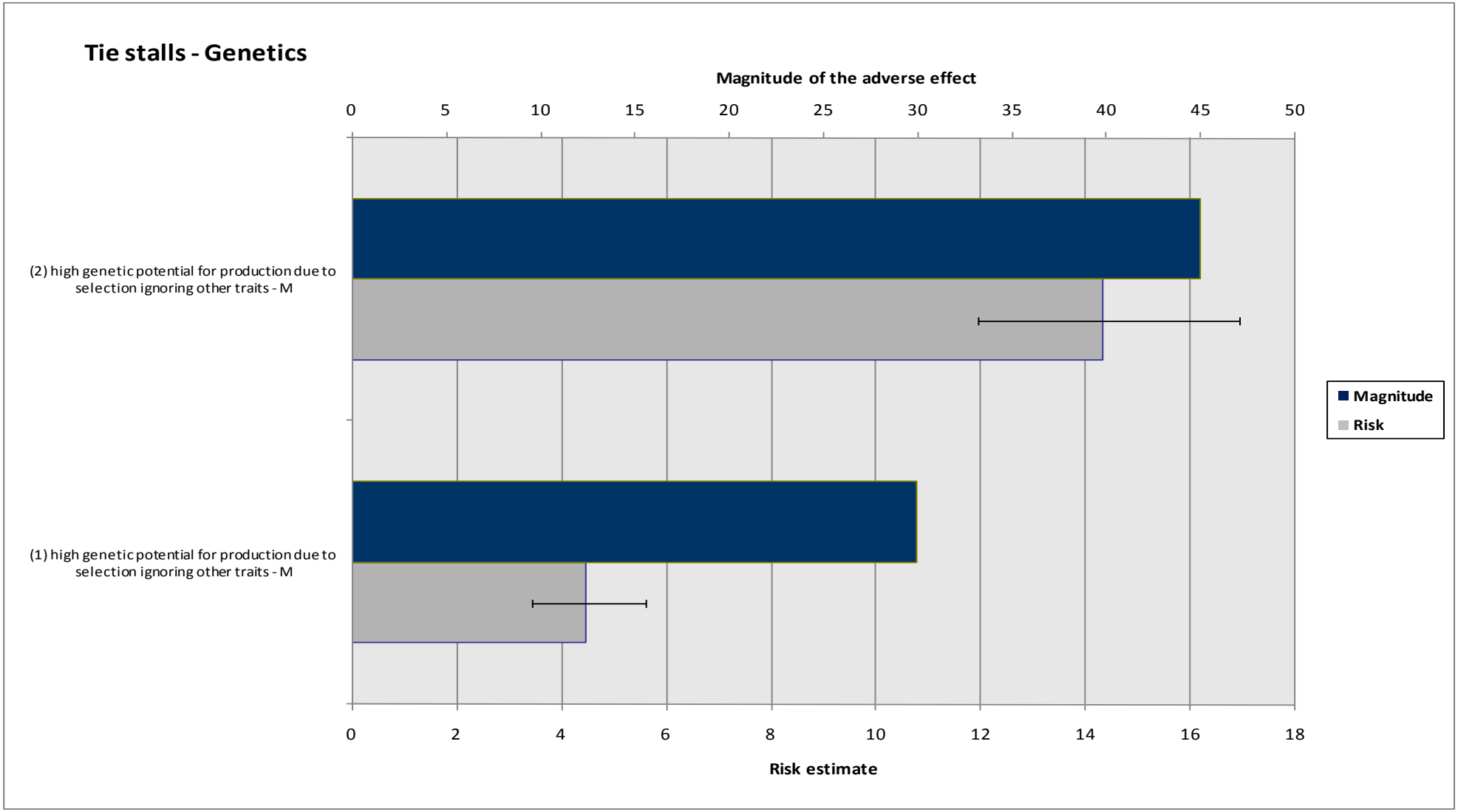

Figure 18. Ranking of hazards related to genetics in dairy cows kept in tie-stalls.

STRAW YARDS				LEG & LOCOMOTION DISORDERS																
	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	Qualitative uncertainty
							min	ml	max				min	ml	max				
HOUSING																			
5.1 / 6.1	1	**incorrect positioning or design of feeding installation**	--	foot disorders, pain	2	60	5	10	15	M	365	full exposure	10	20	30	M	0.6	30	M
6.7	2	**Inadequate bedding**	hygiene, composition and quantity	foot disorders, pain	2	30	50	60	70	M	365	full exposure	30	50	70	M	4.5	15	M
6.1	3	**Inadequate floor in area where cows walk**	too slippery, too hard, injuring, too rough at feed face	leg injuries, claw disorders, pain	3	60	10	20	30	L	365	full exposure	30	50	70	M	4.5	45	M
12.3	4	**Lack of facilities for sick / injured animals**	hospital pens	poor recovery, pain	3	60	15	20	25	M	365	full exposure	50	70	90	H	6.3	45	H
12.3	5	**Lack of facilities for sick / injured animals**	foot baths	disease transmission (e.g. digital dermatitis)	3	60	50	60	70	M	365	full exposure	20	25	30	H	6.75	45	H
13.1	6	**Inadequate or lack of handling/restraining facilities**	--	leg injuries, claw disorders, pain	3	60	60	70	80	L	10	full exposure	30	50	70	H	15.75	45	H
6.9	7	**Poor maintenance of flooring ***	repair, manure, floor hygiene	leg injuries, claw disorders, pain	3	60	50	60	70	L	365	full exposure	15	30	50	H	8.1	45	H
6.1	8	**too few feeding places in zero grazing systems**	--	leg injuries, claw disorders, pain	2	40	10	15	20	M	365	> 1 cow per place	5	10	15	H	0.3	20	H
6.1	9	**Inadequate design of waiting area**	size, flooring, crowding gates	leg injuries, claw disorders, pain	3	60	5	10	15	M	305	full exposure	15	30	45	H	1.35	45	H

Figure 19. Risk assessment hazards related to housing in dairy cows kept in straw yards.

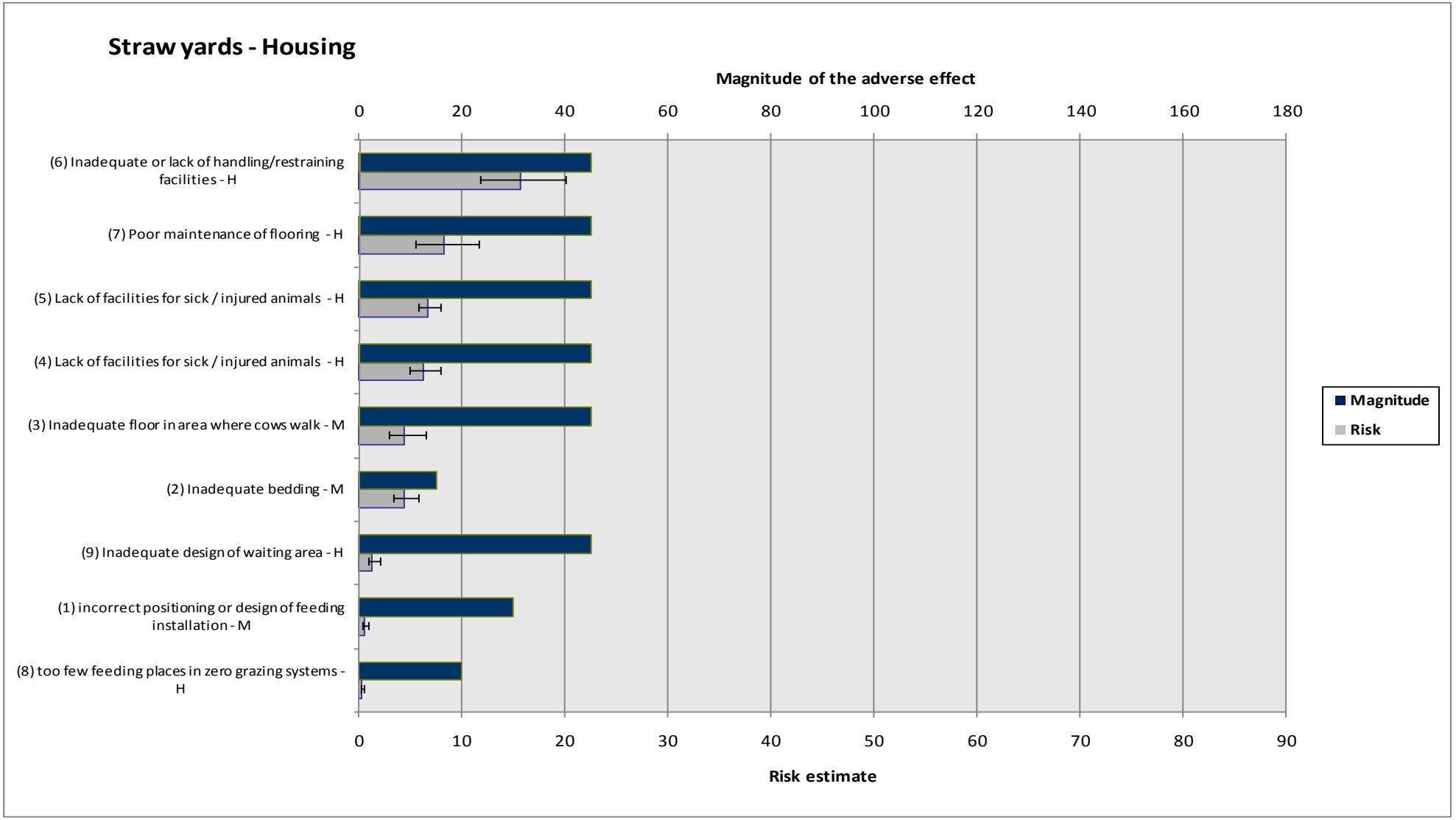

Figure 20. Ranking of hazards related to housing in dairy cows kept in straw yards.

STRAW YARDS				LEG & LOCOMOTION DISORDERS																
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				
NUTRITION AND FEEDING																			
5.1	1	**Poor feed quality (roughage)**	wet silage	infectious foot diseases, pain	3	10	10	20	30	M	100	< 25 % DM	20	30	40	H	0.45	7.5	H
5.1	2	**Improper ration composition**	Inadequate fibre/carbohydrate ratio and fibre quality/lenght	claw disorders, laminitis, pain	3	60	10	15	20	L	325	rumen pH < 5.8 more than 3 hours	5	10	15	H	0.68	45	H
5.1	3	**Inadequate transition feeding**	Inadequate feeding strategy, energy and fibre supply	claw disorders, laminitis, pain	3	60	5	10	15	M	45	See S. Report Chapter 10	30	50	70	M	2.25	45	M
5.1	4	**Overfeeding**	excess of nutrient supply in relation to genotype and energy output at the end of lactation and dry period	claw disorders, laminitis, pain	3	60	1	5	10	M	100	BCS > 3.75	15	20	25	M	0.45	45	M

Figure 21. Risk assessment hazards related to nutrition and feeding in dairy cows kept in straw yards.

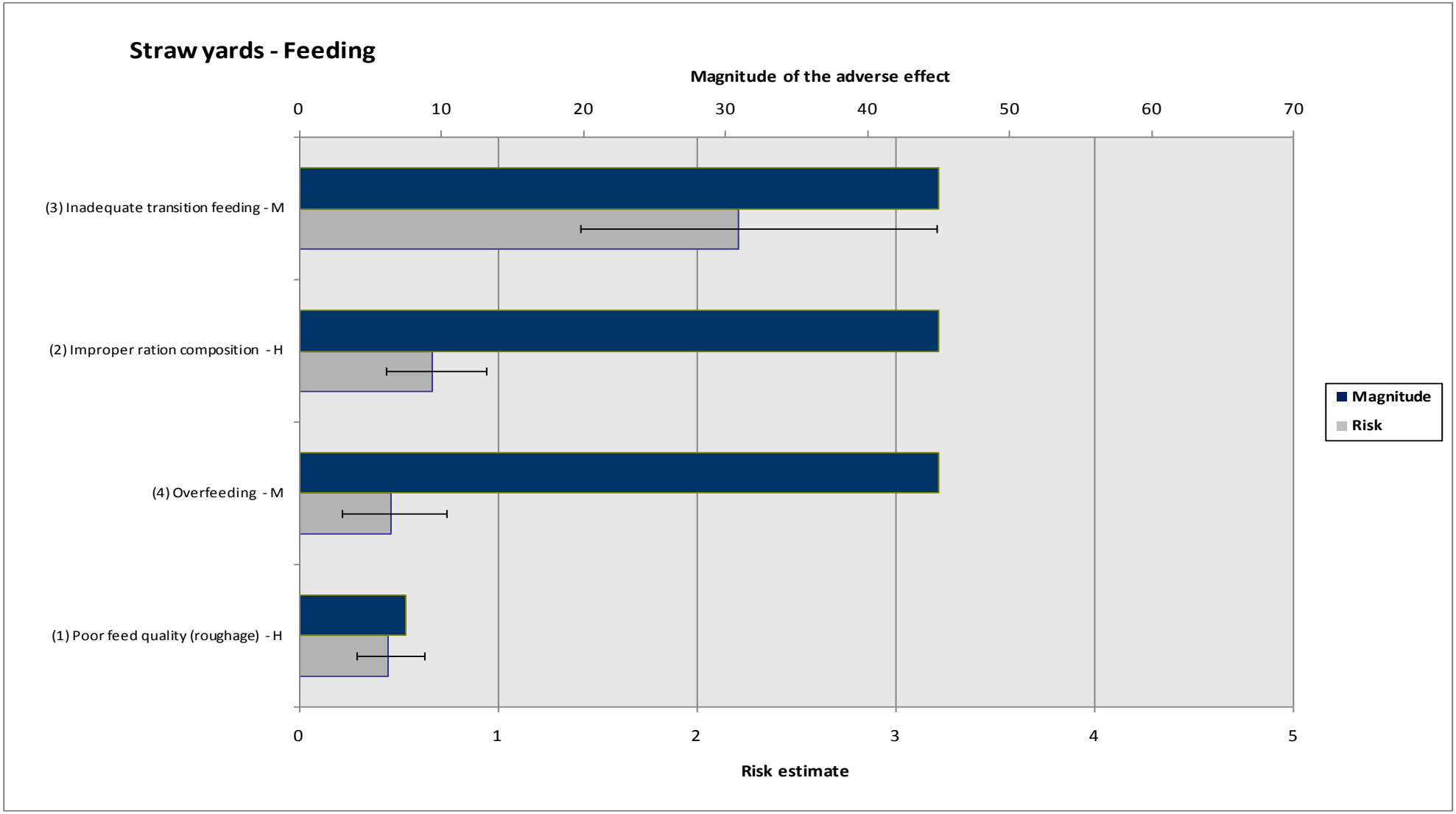

Figure 22. Ranking of hazards related to feeding in dairy cows kept in straw yards.

STRAW YARDS				LEG & LOCOMOTION DISORDERS																
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				
MANAGEMENT																			
8.1	1	**Mixing animals from different groups**	the single animal is moved to another group	foot injuries, infectious foot disorders, pain	2	30	5	10	15	M	5	full exposure	98	99	100	M	1.49	15	M
14	2	**Insufficient or inappropriate care of animals by stockperson**	delayed detection of lameness due to negligence /lack of knowledge	foot injuries, infectious foot disorders, pain	4	60	70	80	90	L	365	full exposure	20	30	40	M	14.40	60	M
9.3/9.6	3	**Inadequate preventive medicine, herd health managment**	inadequate foot hygiene (e.g. foot bathing)	infectious foot disorders, pain	3	60	40	50	60	L	365	full exposure	40	60	80	H	13.50	45	H
12.3	4	**Inadeqate biosecurity**	introducing infections particularly to heifers e.g. by contaminated environment	infectious foot disorders (e.g. digital dermatitis), pain	3	60	50	60	70	M	365	full exposure	20	25	30	H	6.75	45	H
9.3/9.6	5	**Witholding necessary therapeutic health care**	failure to treat early lameness	claw disorders, infectious foot disorders, pain	4	60	70	80	90	L	40	full exposure	10	20	30	H	9.60	60	H

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

STRAW YARDS				LEG & LOCOMOTION DISORDERS																
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				
MANAGEMENT																			
9.3	6	**poor health care and welfare plan**	absence of preventive functional trimming	claw disorders, infectious foot disorders, pain	3	60	20	30	40	L	180	full exposure	50	60	70	H	8.10	45	H
9.3/9.4 /9.6	7	**Inadequate clinical health monitoring**	including recording and planning e.g. claw disease	claw disorders, infectious foot disorders, pain	3	60	10	20	30	M	365	full exposure	40	70	90	H	6.30	45	H
13.8	8	**Improper analgesia during procedure**	Treatment of claw lesions	pain	4	10	98	99	100	L	3	full exposure	15	20	25	M	1.98	10	M
13.7	9	**Downer cow**	Improper management of downer cows - Lack of: physiotherapy, good bedding, proper facilities and lifting devices	paralysis, pain	4	5	98	99	100	L	15	full exposure	0.5	1	1.5	M	0.05	5	M

Figure 24. Risk assessment hazards related to management in dairy cows kept in straw yards (continued).

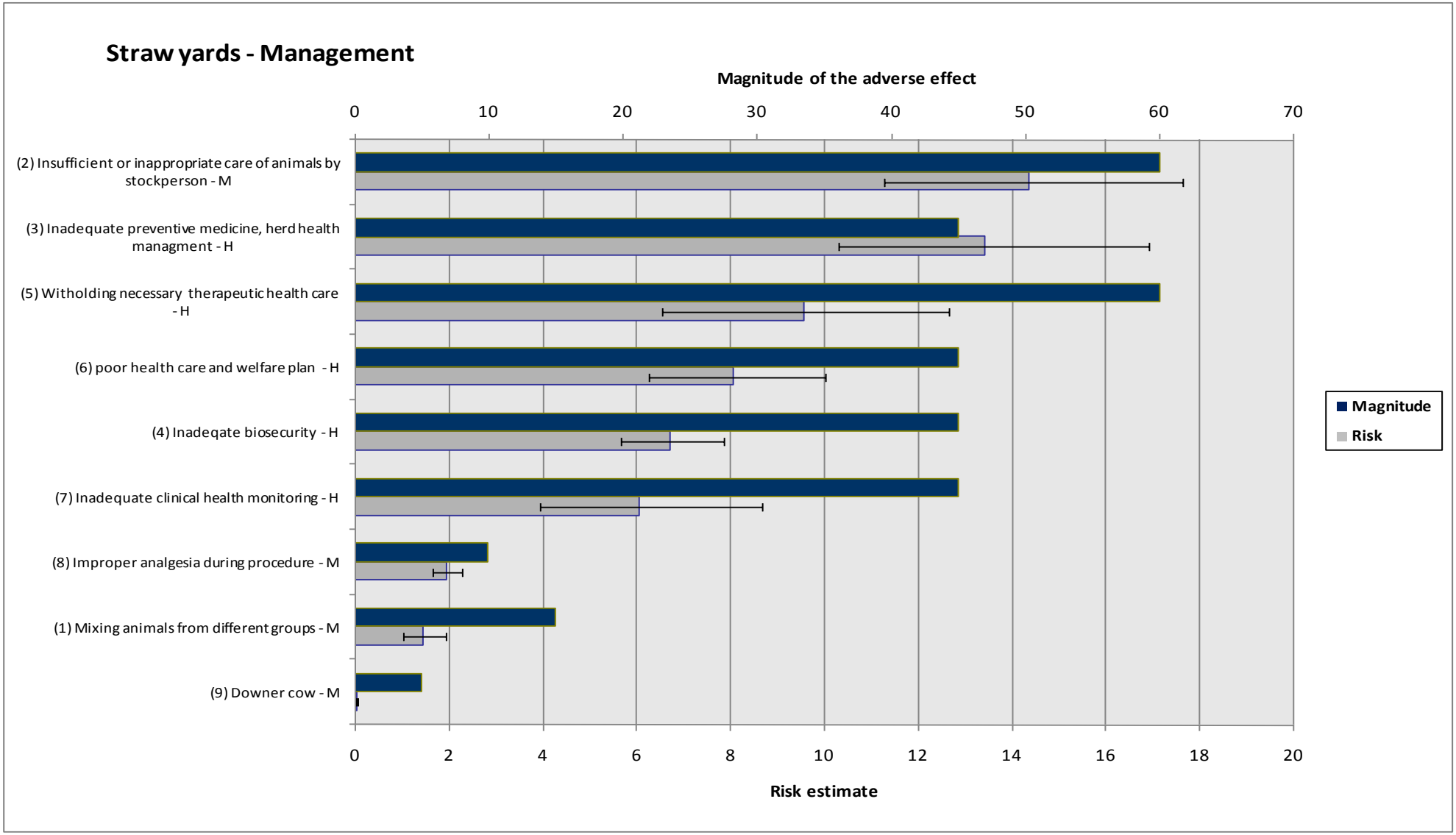

Figure 25. Ranking of hazards related to management in dairy cows kept in straw yards.

STRAW YARDS				LEG & LOCOMOTION DISORDERS																
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				
GENETICS																			
4.2	1	**high genetic potential for production due to selection ignoring other traits**	with good housing, nutrition and management	leg injuries, claw disorders, pain	3	40	40	50	60	L	365	estimated breeding value for yield in top quartile for breed and country	20	30	40	M	4.50	30	M
4.2	2	**high genetic potential for production due to selection ignoring other traits**	without good housing, nutrition and management	leg injuries, claw disorders, pain	3	60	70	80	90	M	365	estimated breeding value for yield in top quartile for breed and country	30	40	50	M	14.40	45	M

Figure 26. Risk assessment hazards related to genetics in dairy cows kept in straw yards.

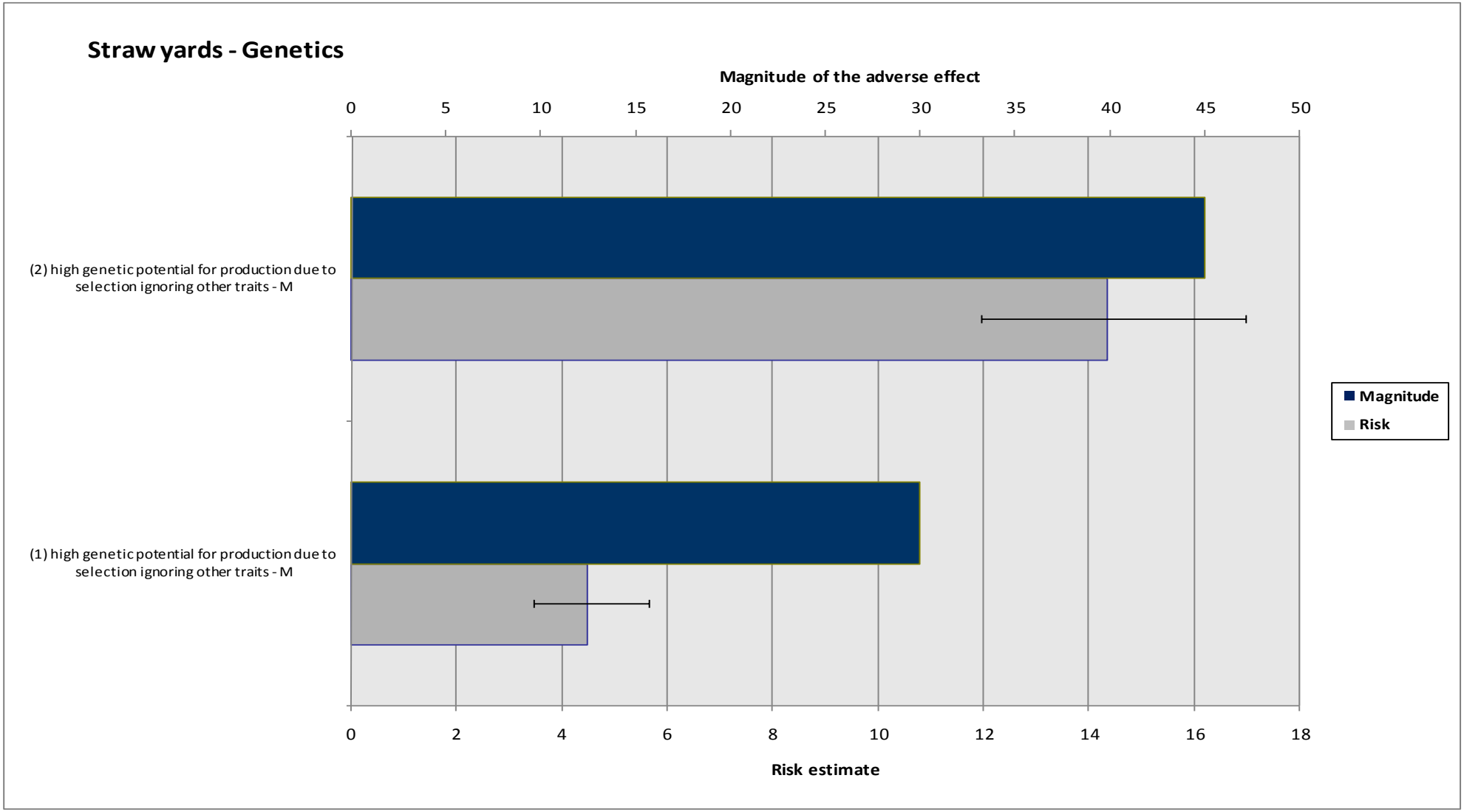

Figure 27. Ranking of hazards related to genetics in dairy cows kept in straw yards.

PASTURE				LEG & LOCOMOTION DISORDERS																
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/ ENVIRONMENT																			
6.8	1	**Inadequate pasture**	Wet, muddy, stony	foot injuries, infectious foot disorders, pain	3	60	30	40	50	M	180	full exposure	10	30	50	H	5.40	45	H
12.3	2	**Lack of facilities for sick / injured animals**	hospital pens	poor recovery, pain	3	60	15	20	25	M	180	full exposure	50	70	90	H	6.30	45	H
12.3	3	**Lack of facilities for sick / injured animals**	foot baths	disease transmission (e.g. digital dermatitis)	3	60	50	60	70	M	180	full exposure	20	25	30	H	6.75	45	H
13.1	4	**Inadequate or lack of handling/restraining facilities**	--	leg injuries, claw disorders, pain	3	60	60	70	80	L	10	full exposure	30	50	70	H	15.75	45	H
6.1	5	**Inadequate design of waiting area**	size, flooring, crowding gates	fear, injuries, pain, social stress,	2	60	5	10	15	M	180	full exposure	15	30	45	H	0.90	30	H
6.1	6	**Walking tracks too long, or poorly maintained**	pathways uneven, stony, too slippery or too hard	leg injuries, claw disorders, pain	3	60	30	40	50	L	180	> 0.5 Km	15	30	50	H	5.40	45	H

Figure 28. Risk assessment hazards related to housing in dairy cows kept in pasture.

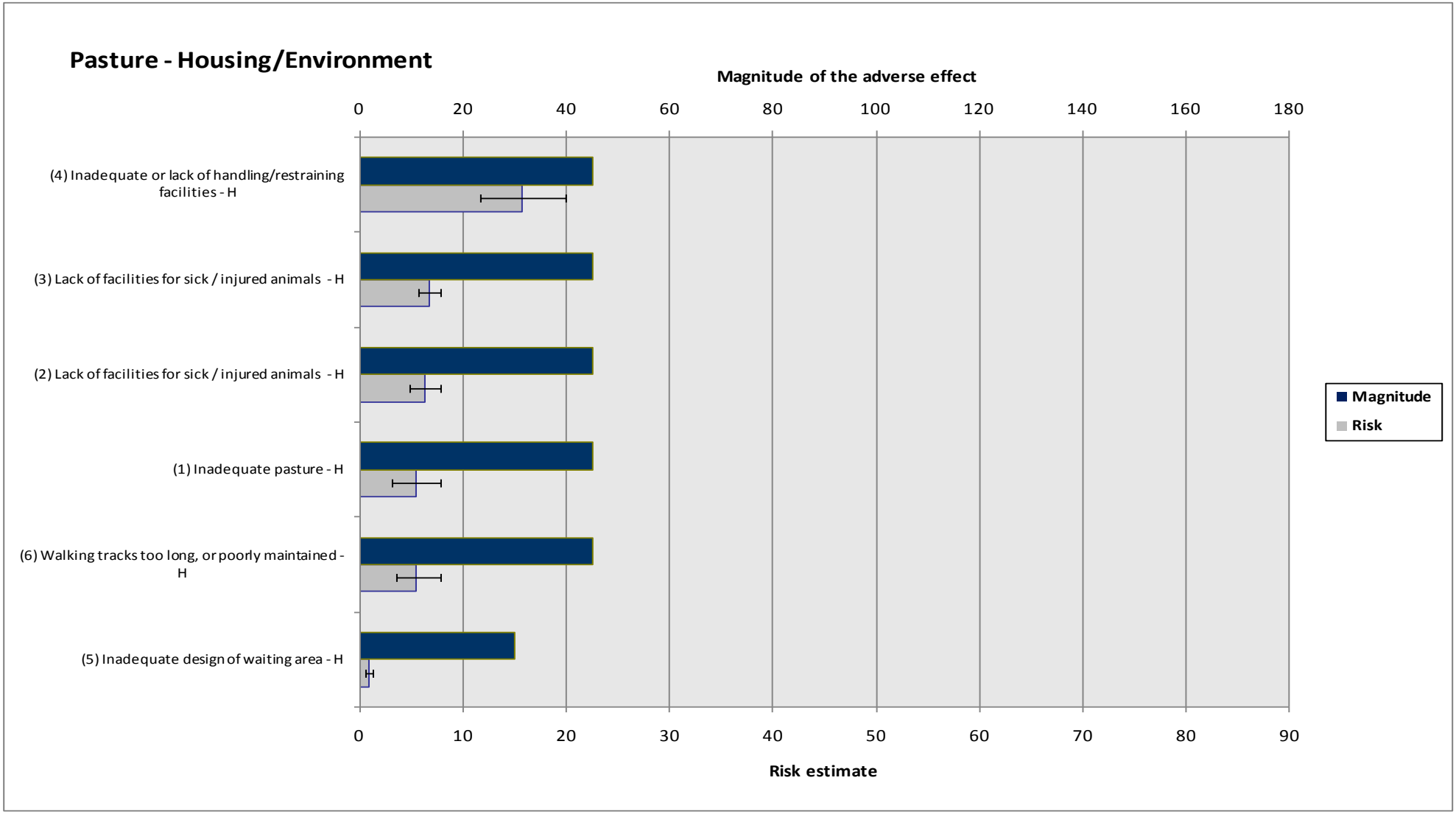

Figure 29. Ranking of hazards related to housing in dairy cows kept in pasture.

PASTURE	LEG & LOCOMOTION DISORDERS																		
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				
MANAGEMENT																			
13.1	1	**Mixing animals from different groups**	the single animal is moved to another group	foot injuries, infectious foot disorders, pain	2	30	5	10	15	M	5	full exposure	98	99	100	M	1.49	15	M
14	2	**Insufficient or inappropriate care of animals by stockperson**	delayed detection of lameness due to negligence /lack of knowledge	foot injuries, infectious foot disorders, pain	3	30	30	40	50	L	180	full exposure	20	30	40	M	2.70	22.5	M
9.3/9.6	3	**Inadequate preventive medicine, herd-health management**	inadequate foot hygiene (e.g. foot bathing)	infectious foot disorders, pain	3	30	10	20	30	L	180	full exposure	40	60	80	H	2.70	22.5	H
12.3	4	**Inadeqate biosecurity**	introducing infections particularly to heifers e.g. by contaminated environment	infectious foot disorders (e.g. digital dermatitis), pain	3	30	20	30	40	M	180	full exposure	20	25	30	H	1.69	22.5	H
9.3/9.6	5	**Witholding necessary therapeutic health care**	failure to treat early lameness	claw disorders, infectious foot disorders, pain	3	30	20	30	40	L	30	full exposure	10	20	30	H	1.35	22.5	H

Figure 30. Risk assessment hazards related to management in dairy cows kept in pasture.

PASTURE	LEG & LOCOMOTION DISORDERS																			
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				
MANAGEMENT																			
9.3	6	**poor health care and welfare plan**	absence of preventive functional trimming	claw disorders, infectious foot disorders, pain	3	60	20	30	40	L	180	full exposure	50	60	70	H	8.10	45	H
9.3/9.4/9.6	7	**Inadequate clinical health monitoring**	including recording and planning e.g. claw disease	claw disorders, infectious foot disorders, pain	3	60	10	20	30	M	180	full exposure	40	70	90	H	6.30	45	H
13.8	8	**Improper analgesia during procedure**	Treatment of claw lesions	pain	4	10	98	99	100	L	3	full exposure	15	20	25	M	1.98	10	M
13.7	9	**Downer cow**	Improper management of downer cows - Lack of: physiotherapy, good bedding, proper facilities and lifting devices	paralysis, pain	4	5	98	99	100	L	15	full exposure	0.5	1	1.5	M	0.05	5	M

Figure 31. Risk assessment hazards related to management in dairy cows kept in pasture (continued).

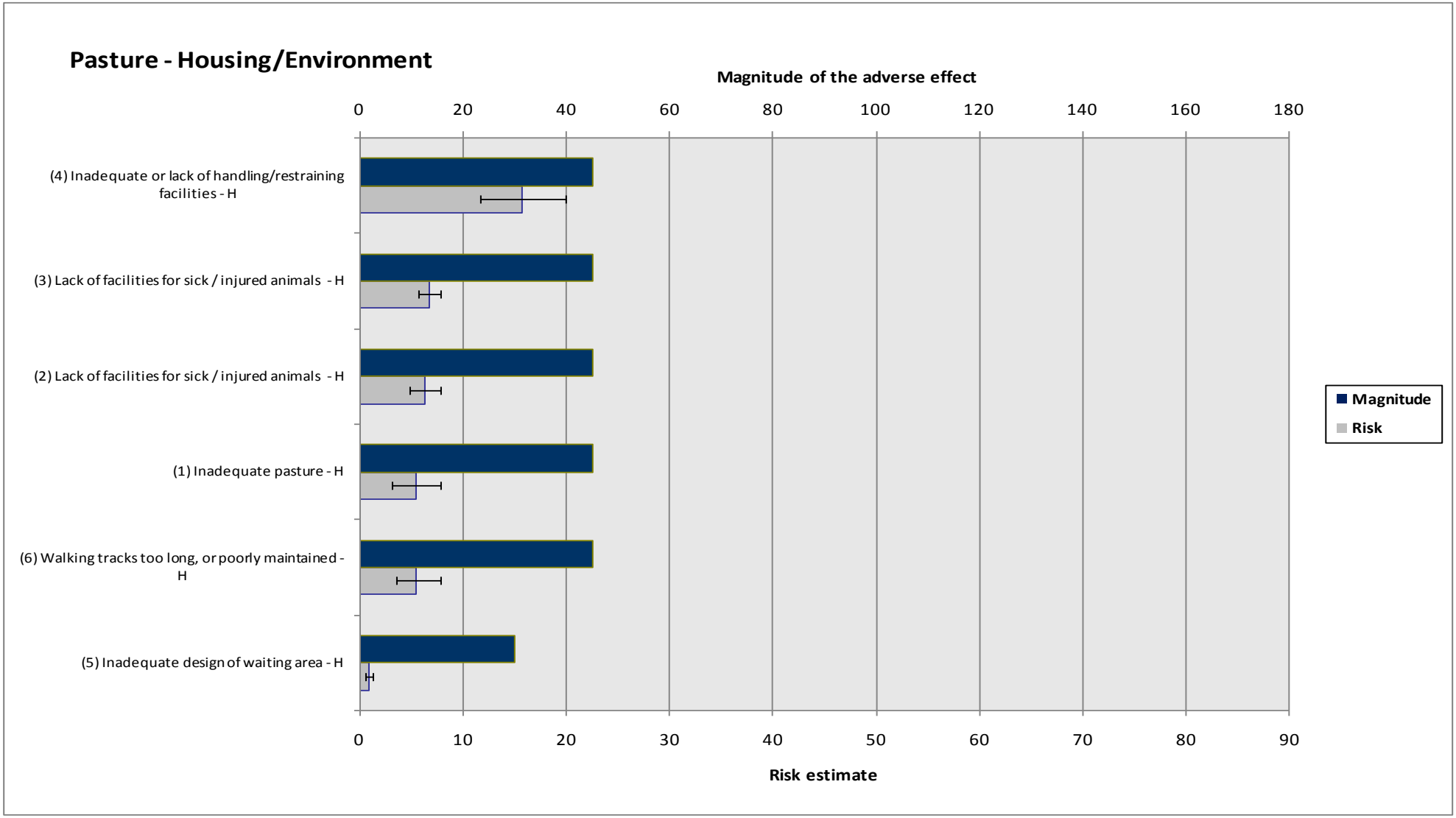

Figure 32. Ranking of hazards related to management in dairy cows kept in pasture.

PASTURE				LEG & LOCOMOTION DISORDERS																
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				
GENETICS																			
4.2	1	**high genetic potential for production due to selection ignoring other traits**	with good nutrition and management	leg injuries, claw disorders, pain	2	30	20	30	40	L	180	estimated breeding value for yield in top quartile for breed and country	20	30	40	M	1.35	15	M
4.2	2	**high genetic potential for production due to selection ignoring other traits**	without good nutrition and management	leg injuries, claw disorders, pain	2	50	30	40	50	M	180	estimated breeding value for yield in top quartile for breed and country	20	30	40	M	3.00	25	M

Figure 33. Risk assessment hazards related to genetics in dairy cows kept in pasture.

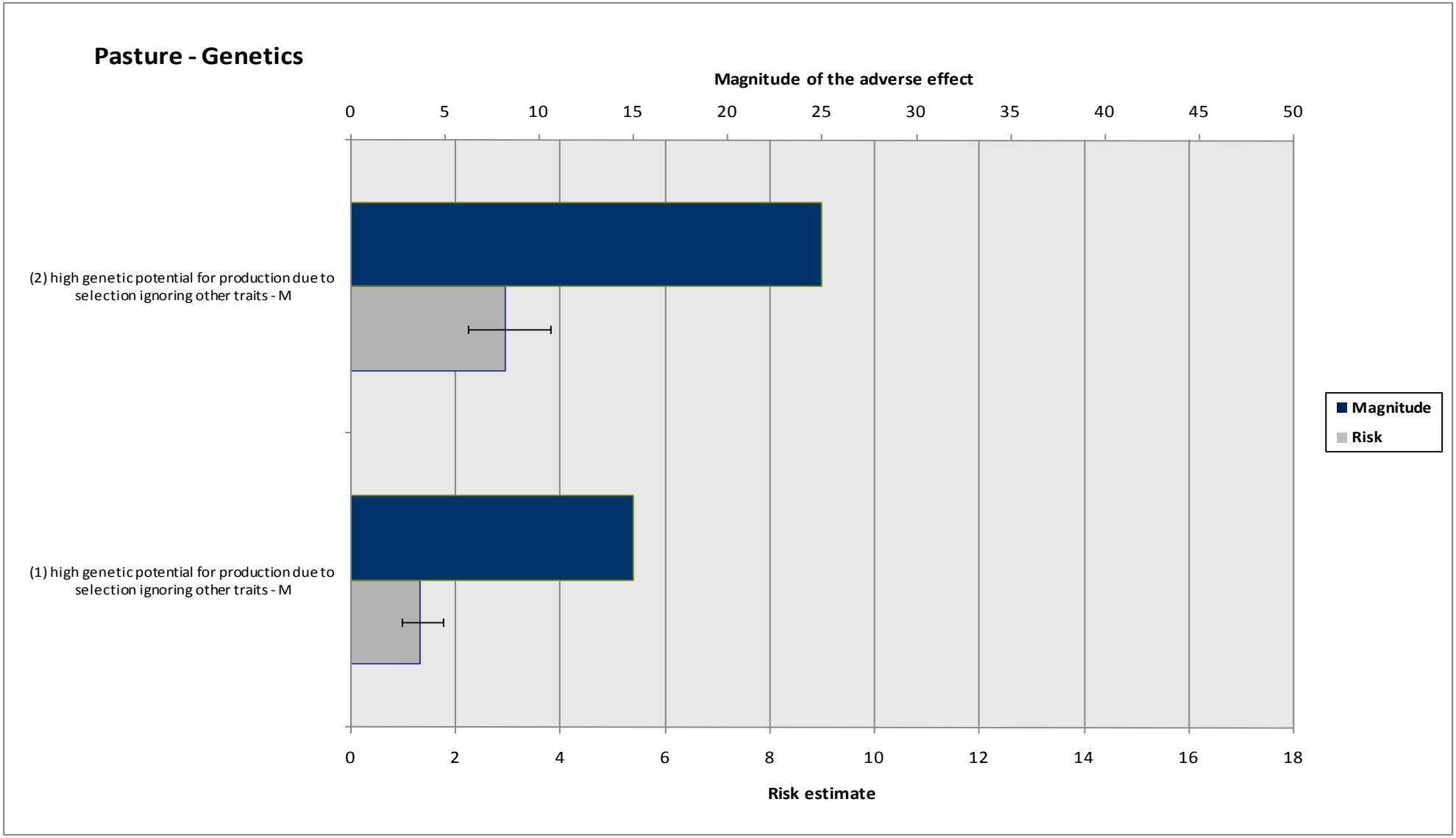

Figure 34. Ranking of hazards related to genetics in dairy cows kept in pasture.

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.