

**Scientific opinion on welfare of dairy cows in relation to behaviour, fear and pain
based on a risk assessment with special reference to the impact of housing, feeding, management and genetic selection¹**

Scientific Opinion of the Panel on Animal Health and Animal Welfare

(Question No EFSA-Q-2008-340)

Adopted on 05 June 2009

This opinion, published on 8 October 2009, replaces the earlier version published on 9 July 2009².

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.

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 behaviour, fear and pain problems in dairy cows. *The EFSA Journal* (2009) 1139, 1-68

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.

* A minority opinion was expressed by 6 members of the Panel (see page 17).

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 iii) 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 behaviour, fear and pain, 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 behaviour problems, fear and pain can be dependent of the farming systems. In the risk assessment, the risk estimates for behavioural problems, fear and pain associated with housing were generally higher than the risk estimates observed for the other categories of hazards. The risk estimates for behavioural problems, fear and pain associated with housing were highest for tie-stalls and lowest for cows at pasture, and were lower in straw yards than in cubicle housing.

According to the scoring system used in this analysis, among the highest ranked hazards in terms of risk estimate in relation to the housing were design of stalls and inadequate bedding in both tie-stalls and cubicle housing. In cubicle houses, inappropriate flooring where cows walk posed the largest risk estimate for behavioural problems whereas having fewer cubicles than cows was the hazard with the largest magnitude of the adverse effect, but the risk estimate was relatively low. Poor air quality was rated as a hazard with a large magnitude of the adverse effect in all types of indoor housing. However, the degree of exposure was low, resulting in low risks for behavioural problems. For cows at pasture, hazards associated with housing have much lower magnitude of the adverse effect than for cows housed indoors. For cows at pasture, the largest risk estimates for behavioural problems were associated with inappropriate temperature and humidity, lack of handling facilities and problems with the milking parlour and waiting areas. The highest ranked hazards associated with straw yards were inadequate bedding, lack of space, zero grazing and inadequate flooring where cows walk. Finally, zero-grazing was rated as a hazard with a large magnitude of the adverse effect on cow behaviour, fear and pain in tie-stalls, straw yards and cubicle housing, but the risk estimate was relatively low.

In relation to the use of tie stalls, Panel members concluded that tie-stalls restrict the voluntary movement and social behaviour of dairy cows. When periods of exercise are possible some of the adverse effects are reduced. Therefore, systems of husbandry and management should involve a minimum time of restricted movement in order that all dairy cows are able to meet their need to show certain behaviours such as grooming, social interaction and exercise. While tie-stall use continues, cows should have daily exercise that involves walking freely inside or outside (except where there are adverse climatic conditions) and also the freedom to carry out other behaviours. A minority opinion on the use of tie-stalls was expressed by some Panel members.

The risk assessment showed that nutrition and feeding hazards have a lower risk of causing behavioural problems compared with other factors. The risk estimates and magnitudes of the adverse effects of behavioural problems associated with nutrition and feeding were quite similar for cubicle housing, tie-stalls and straw yards; however there were fewer hazards

identified for pasture. The highest risk estimate for behavioural problems due to nutrition and feeding was associated with improper ration composition and underfeeding in cubicle houses, tie-stalls and straw yards. However, the magnitudes of the adverse effects were highest for poor feed quality of the roughage, improper ration composition, underfeeding, and improper sensory quality of the water source.

As regards the management aspects for dairy cows, the maintenance of stable groups ensures that long-lasting affiliative relationships can continue, reducing the overall stress level in cows. In the risk assessment, the hazard with the highest or second highest magnitude of the adverse effect in the three systems where animals are kept loose was mixing animals from different groups. Husbandry practices should avoid regrouping of dairy cows in order to facilitate continuation of long-lasting social bonds, avoid frequent disruption and provide social stability. If social mixing of dairy cows is unavoidable, stress should be reduced by providing larger space allowance during grouping in buildings or on pasture. Regrouping or mixing on pasture is ideal as it offers space and good flooring. Appropriate management, together with larger space allowance, can minimize social agonistic interactions in the herd in general. When cows have to calve in groups indoors, this may cause disturbance for the cow. An individual calving pen with some visual and auditory contact with other cows gives the cow the best possibility to show normal behaviour and calve without problems. Dairy cows allowed to stay with their calf after birth and separated within 24 h show a mild stress reaction after separation. After the mother-young bond has been established, i.e. 2 days or more, the cow shows a stronger reaction after separation, and this reaction becomes stronger the longer the time that they stay together. Some infectious diseases may be transmitted from the cow to the calf at birth, and then an important measure for reducing disease transmission is to separate the calf very shortly after birth. If the cow is placed out of hearing and sight of the calf, the stress reaction of the cow is lower. When cow and calf have been together for prolonged suckling, e.g. 6-12 weeks, weaning plates placed on the calves reduce the stress reaction in the cow after separation.

In the risk assessment, genetic selection for high milk yield with insufficient emphasis on other traits relating to fitness showed a very low risk of causing behavioural problems compared with other factors and no differences were observed among the different housing systems analysed. The magnitude of the adverse effect and the risk estimate for behavioural problems was highest for cows with high genetic potential for production due to selection ignoring other traits when the housing, nutrition and management are not optimized.

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

TABLE OF CONTENTS

Panel Members 1

Summary 1

Table of Contents 4

Background as provided by the European Commission 5

Terms of Reference as provided by the European Commission 5

Acknowledgements 6

Assessment 7

1. Risk assessment on animal welfare 7

 1.1. Steps of the Risk Assessment 7

 1.1.1. Definition of the target populations / farming systems scenarios 8

 1.1.2. Hazard identification 8

 1.1.3. Hazard Characterisation 9

 1.1.4. Exposure assessment 10

 1.1.5. Risk Characterisation 12

 1.2. Graphical presentation of the Risk Characterisation 13

 1.2.1. Notes to the reader 14

Conclusions and Recommendations 14

Documentations provided to efsa 19

References 19

Appendices **Error! Bookmark not defined.**

Glossary: Risk Analysis Terminology 65

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. The 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 behaviour, fear and pain in dairy cows.

ACKNOWLEDGEMENTS

The European Food Safety Authority and the AHAW Panel wish to thank the members of the Working Group: Donald Broom, Bo Algers, Joerg Hartung, Frans Smulders, Telmo Nunes, Lene Munksgaard, Lena Lidfors, Pascal Oltenacu, Susanne Waiblinger and Jeffrey Rushen 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 it 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:

$$\text{Magnitude of the adverse effect} = (\text{Severity score}/4) * \text{Duration of the effect}$$

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 - $< 5\text{ }^{\circ}\text{C}$ or too high - $> 25\text{ }^{\circ}\text{C}$) 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:

$$\text{Risk estimate} = (\text{Severity score}/4) * (\text{Duration of the effect}) * (\text{Likelihood of the adverse effect}) * (\text{Likelihood of exposure to the hazard})$$

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) c. Running numbers in the first column of the Tables cross reference the hazards in the chart.
- 4) 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.
- 5) 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.
- 6) 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 AND RECOMMENDATIONS

A general conclusion from the risk assessment was that the presence of behaviour, fear and pain problems in relation to the hazards considered can be dependent on the farming systems. The risk estimates for behavioural problems, fear and pain associated with housing were generally higher than the risk estimates observed for the other categories of hazards.

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

- From the **risk assessment** it was concluded that hazards related to genetics show a very low risk of causing behavioural problems compared with other factors. The magnitude of the adverse effect and the risk estimate for behavioural problems was highest for cows with high genetic potential for production due to selection ignoring other traits when the housing, nutrition and management are not optimised.

Chapter 5 - Nutrition and major metabolic disorders in relation to welfare

- The **risk assessment** showed that nutrition and feeding hazards have a relatively low risk of causing behavioural problems in comparison with some housing factors. The risk estimates and magnitudes of the adverse effects of behavioural problems associated with nutrition and feeding were quite similar for cubicle housing, tie-stalls and straw yards; however there were fewer hazards identified for pasture.
- In the **risk assessment**, the highest risk estimate for behavioural problems due to nutrition and feeding was associated with improper ration composition and underfeeding in cubicle houses, tie-stalls and straw yards.
- In the **risk assessment**, the magnitudes of the adverse effects were highest for poor feed quality of the roughage, improper ration composition, underfeeding, and improper sensory quality of the water source.
- The **risk assessment** showed that the uncertainty on the bibliographic evidence about the risk estimates is high for all hazards, except for underfeeding where it is medium.

Chapter 6 - Housing conditions in relation to welfare

6.1 Building design

Conclusions

- In the **risk assessment**, the risk estimates for behavioural problems, fear and pain associated with the housing/environment conditions were highest for tie-stalls, relatively high for cubicle houses, much lower for straw yards and very low for pasture.
- In the **risk assessment**, the highest overall risk for behavioural problems due to housing was associated with poor stall design in tie-stall housing.
- From the **risk assessment** it was concluded that design of the stalls and inadequate bedding are some of the highest risks for behavioural problems in both tie-stalls and cubicle housing.

6.1.4 Walking areas

Conclusions

- The **risk assessment** showed that, in cubicle houses, inappropriate flooring in passageways, feeding and milking areas posed the largest risk for welfare associated with behavioural problems, fear and pain.

6.2 Space allowance

Conclusions

- In the **risk assessment**, having fewer cubicles than cows was the hazard with the largest magnitude of the adverse effect in cubicle houses, but the risk estimate was relatively low. There was a high degree of uncertainty about the estimates of exposure.

Recommendations

- The tie length and tie stall design should allow the cow to easily reach food and water and to lie down and stand up without difficulties showing normal behavioural pattern.

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

Conclusions

- In the **risk assessment**, poor air quality was rated as a hazard with a large magnitude of the adverse effect in all types of indoor housing. However, the degree of exposure was low, resulting in low risks for behavioural problems. There was a high degree of uncertainty about the estimates of exposure.
- The **risk assessment** showed that, for cows at pasture, hazards associated with housing/environment conditions have much lower magnitude of the adverse effect than for cows housed indoors. The largest risk estimates for cows at pasture for behavioural problems were associated with inappropriate temperature and humidity (in particular when there is no shelter), lack of handling facilities and problems with the milking parlour and waiting areas.

6.7 Bedding

Conclusions

- The **risk assessment** showed that the highest ranked hazards associated with straw yards were inadequate bedding, lack of space, zero grazing and inadequate flooring where cows walk.

6.8 Locomotion, exercising and use of pasture

Conclusions

- In the **risk assessment**, zero-grazing was rated as a hazard with a large magnitude of the adverse effect for cows in tie-stalls, straw yards and cubicle housing, but the risk estimate was relatively low. There was a high degree of uncertainty about the estimates of exposure.
- Tie-stalls restrict the voluntary movement and social behaviour of dairy cows. When periods of exercise are possible some of the adverse effects are reduced.

Recommendations

- Systems of husbandry and management should involve a minimum time of restricted movement in order that all dairy cows are able to meet their need to show certain behaviours such as grooming, social interaction and exercise.

- Therefore, if tie-stalls are used the system of management should permit dairy cows the freedom to exercise and groom daily, except when climatic conditions do not permit them to do so.

Recommendations for future research

- Currently there is only a limited amount of scientific data linking the period per day of being tied in a tie stall to levels of disease and overall impact on welfare, so this should be studied.

Minority Opinion by Bo Algers, Harry Blockhuis, Donald Broom, Joerg Hartung, David Morton, Mohan Raj:

In contrast to the Panel majority opinion, it is our opinion that there is sufficient evidence for poor welfare in dairy cattle held in tie-stalls.

It is recommended that dairy cattle should not be routinely kept in tie-stalls as a housing system.

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

8.1. Social grouping

8.1.3 Affiliate relationships and welfare

Conclusions

- Cattle in stable groups have complex, long-lasting affiliative relationships. Maintenance of stable groups ensures that these relationships can continue, reduces the overall stress level in cows and may improve milk production.

8.1.5. Grouping, regrouping and welfare

Conclusions

- The level of stress during regrouping or mixing, however, depends on the management strategy adopted and the housing environment.
- In the **risk assessment**, the hazard with the highest or second highest magnitude of the adverse effect in the three systems where animals are kept loose was mixing animals from different groups (unfamiliar with one another).

Recommendations

- Husbandry practices should avoid regrouping of dairy cows as far as possible in order to facilitate continuation of long-lasting social bonds, avoid frequent disruption and provide social stability.

8.1.8 Group size

Conclusions

- The social environment in dairy cattle is characterised by early separation from the mother and other adult cows, living in same-sex groups throughout life, and frequent changes in herd composition. In large herds the number of aggressive interactions per cow is reported to be greater.

- Regrouping or mixing on pasture is ideal as it offers space and a good surface to stand on. Appropriate management (e.g. ad libitum feeding of good quality food, separating cows in heat), besides larger space allowance, can minimise social agonistic interactions in the herd in general.

Recommendations

- Development and implementation of housing design enabling selective, yield-matched feeding within a herd and thus avoiding regrouping should be supported.
- If social mixing of dairy cows is unavoidable, stress should be reduced by providing larger space allowance during grouping in buildings or on pasture.

Recommendations for future research

- There should be research into appropriate management practices to reduce social stress in dairy cows during grouping or re-grouping.

8.2 Pre-partum Management

Conclusions

- Cows outdoors about to calve will separate from the herd and will hide if there are hiding places available.
- When cows have to calve in groups indoors, this may cause disturbance for the cow. An individual calving pen with some visual and auditory contact with other cows gives the cow the best possibility to show normal behaviour and calve without problems.

Recommendations

- Dairy cows calving in buildings should be moved to individual calving pens with some contact with other cows before calving in order to minimise welfare problems.
- Dairy cow housing and management should ensure that there are sufficient calving pens.

8.4. Separation from the calf

Conclusions

- Dairy cows are more active shortly after parturition if they are left with their calf.
- Foster cows that accept alien calves do not necessarily need to be milked.
- Dairy cows allowed to stay with their calf after birth and separated within 24 h show a mild stress reaction after separation. After the mother-young bond has been established, i.e. 2 days or more, the cow shows a stronger reaction after separation, and this reaction becomes stronger the longer the time that they stay together.
- If the cow is placed out of hearing and sight of the calf, the stress reaction of the cow is lower. When cow and calf have been together for prolonged suckling, e.g. 6-12 weeks, weaning plates placed on the calves reduce the stress reaction in the cow after separation.
- There are conflicting research data as to whether it is best for the welfare of the cow to leave the calf with the cow for a prolonged lactation period or to remove it within 24 h.

Recommendations

- At separation cow and calf should be placed so that they cannot hear or see each other. When the cow has nursed her calf for the whole milk period or when she has been a foster cow weaning plates on the muzzle of the calf should be used.

Recommendations for further research

- The duration and management of the period during which calves should remain with the cow after parturition should be further studied.
- The optimal time and procedure for separating the calf from the cow needs to be further investigated.

Chapter 13 - Handling in relation to welfare

13.1 Human-animal relationship

Conclusions

- Fear of humans is exacerbated by poor handling methods and reduced by appropriate experience of human contact. Calm and gentle contact with cattle improves later welfare and production.
- The use of aversive handling techniques, such as electric cattle prods, hitting with sticks, vigorous tail-twisting and excessive fear-inducing behaviour all cause poor welfare in cows and tend to reduce ease of handling in the future and productivity.

Recommendations

In order to improve welfare and production, young cattle should be given appropriate experience of human contact and all cattle should be handled calmly with gentle contact.

13.2 On farm monitoring

Conclusions

- The **risk assessment** showed that withholding necessary veterinary therapeutic health care/poor health care and welfare plan is the hazard with the highest or second highest risk estimate in all the systems.
- In the **risk assessment**, the magnitude of the adverse effect and the risk estimate are not very high for withholding necessary veterinary therapeutic health care, mixing of animals as well as for improper analgesia. These hazards might very well lead to extremely poor welfare and thus unnecessary suffering, although for short periods and only for a smaller number of animals.

DOCUMENTATIONS 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.

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 (with aspects of management)																			
6.5.	1	Insufficient light level (day/night)	too dark (for both cows and stockperson)	inability to carry out normal behaviour	1	22	99	99.5	100	H	45	< 40 lux	5	10	15	M	0.54725	5.5	H
6.5.	2	light duration	too short	inability to carry out normal behaviour	1	30	99	99.5	100	H	60	< 6 h	15	30	50	M	2.23875	7.5	H
6.5.	3	light duration	too long	too little rest	1	90	10	20.0	30	H	365	> 18 h	1	3	5	M	0.135	22.5	H
5.1 / 6.1	4	inadequate feeding installation	--	behaviour disruption and prevention, pain	3	90	99	99.5	100	M	365	full exposure	10	20	30	M	13.4325	67.5	M
6.1	5	Poor cubicle design	--	too little rest, behaviour disruption and prevention, pain, fear	3	182	70	80	90	L	365	All year in cubicle house	40	70	90	L	76.44	136.5	L
6.7	6	Inadequate bedding (floor of the cubicle)	Flooring too hard and/or too slippery	too little rest, behaviour disruption and prevention, pain, thermal discomfort, fear	3	182	80	90	100	L	365	All year in cubicle house	30	50	70	M	61.425	136.5	M
6.1	7	Inadequate floor (limited to passage ways, feeding and milking areas)	too slippery, too hard, injuring, too rough	fear of slipping and falling, inhibited maintenance and social behaviour, pain	3	182	99	99.5	100	L	365	All year in cubicle house	50	70	100	M	95.07225	136.5	M
6.2	8	Lack of space, e.g. for exercising and social interactions	--	locomotion problems, behaviour disruption, social stress	2	182	25	50	75	M	365	All year in cubicle house	40	60	80	H	27.3	91	H

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

CUBICLE HOUSES																			
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 (with aspects of management)																			
6.2	9	Fewer cubicles than cows	--	too little rest, locomotion problems, frustration, social stress, behaviour disruption	3	219	10	15	20	M	365	All year in cubicle house	15	25	35	H	6.159375	164.25	H
5.2	10	Insufficient access to water	inappropriate system design	temporary thirst, social stress, frustration, behaviour disruption	2	72	40	50	60	M	365	more than 5 hours water deprivation	5	10	15	H	1.8	36	H
5.2	11	Insufficient access to water	Broken system, poor management	thirst, social stress, frustration, behaviour disruption	3	0.5	99	99.5	100	M	1	total lack of water	0	0.1	0.2	H	0.0004	0.375	H
13.1	12	Inadequate or lack of handling/restraining facilities	---	behaviour disruption and prevention, pain, fear	2	20	60	80	100	H	10	full exposure	30	50	70	H	4	10	H
6.1	13	Inadequate design of waiting area	size, flooring, crowding gates	behaviour disruption and prevention, pain, fear	2	32	50	65	80	H	325	full exposure	15	30	45	H	3.12	16	H
7.2 / 7.3	14	Inadequate milking parlour design	--	behaviour disruption and prevention, pain, fear, frustration	2	16	50	65	80	H	325	full exposure	5	10	15	H	0.52	8	H
7.2 / 7.3	15	Inadequate maintenance of milking equipment	--	pain, fear, frustration	3	16	99	99.5	100	L	60	full exposure	20	30	40	H	3.582	12	H
6.5	16	Inappropriate temperature, humidity	--	thermal discomfort	2	25	50	60	70	M	30	75<THI<78	50	60	70	H	4.5	12.5	H

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

CUBICLE HOUSES																			
Chapter of the scient. report	Hazard identification			Hazard characterization							Exposure assessment						Risk Characterization		
	Hazard N.r.	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 (with aspects of management)																			
6.5	17	Inappropriate temperature, humidity	--	thermal discomfort	3	15	60	70	80	L	15	78<THI<83	40	50	60	H	3.9375	11.25	H
6.5	18	Inappropriate temperature, humidity		thermal discomfort	4	10	90	95	100	L	5	THI>83	10	15	20	H	1.425	10	H
8.2	19	Poor calving conditions	absence of pen, pen design, facilities (inability to separate from other animals)	social stress, fear, pain, behavioural disruption	3	3.5	90	95	100	M	7	full exposure	30	50	70	H	1.246875	2.625	H
6.1	20	too few feeding places in zero grazing systems	--	social stress, hunger, frustration, behaviour disruption	3	90	5	10	20	M	365	> 1 cow per place	15	30	40	H	2.025	67.5	H
3.2 / 6.8	21	zero-grazing with access to outdoors	no access to food outdoors	social stress, behaviour disruption and prevention	2	162	0	40	80	H	325	full exposure	5	10	15	H	3.24	81	H
3.2 / 6.8	22	zero-grazing without access to outdoors	--	social stress, behaviour disruption and prevention	2	182	0	50	100	H	365	full exposure	15	20	25	H	9.1	91	H
6.5	23	Poor air quality (cows with access to pasture)	too high ammonia, bioaerosols and dust	Pain and discomfort	3	60	99	100	100	M	60	inadequate	1	6	10	H	2.7	45	H
6.5	24	Poor air quality (cows kept permanently indoors)	too high ammonia, bioaerosols and dust	Pain and discomfort	3	200	99	100	100	M	200	inadequate	1	6	10	H	9	150	H

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

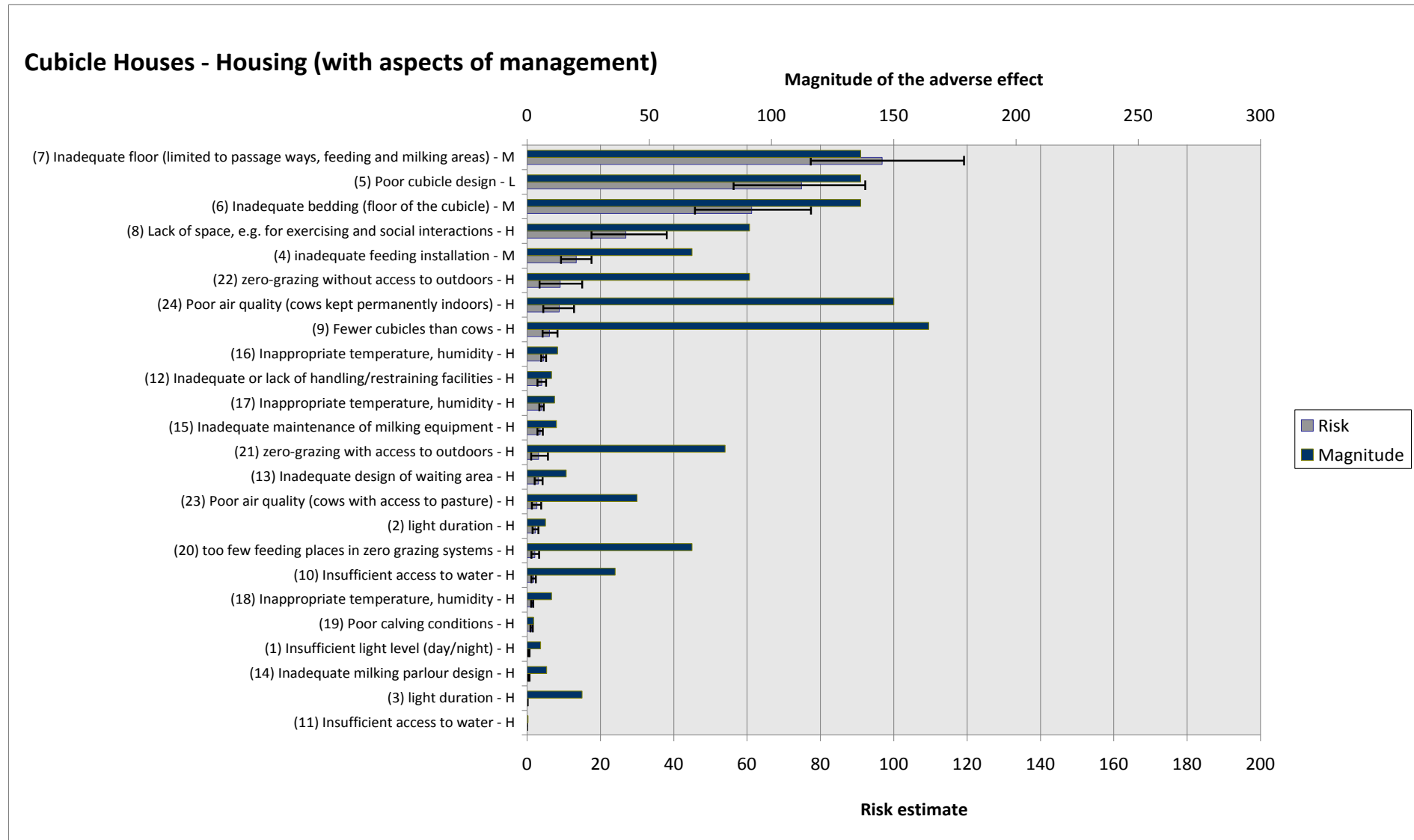


Figure 2. Ranking of hazards related to housing in dairy cows kept in cubicle houses.

CUBICLE HOUSES																			
Chapter of the scient. report	Hazard identification			Hazard characterization						Exposure assessment					Risk Characterization				
	Hazard N°.	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				
FEEDING																			
5.2	1	Water quality: inappropriate water temperature	too high or too low	thirst, frustration, thermal discomfort	1	5	25	50	75	H	60	< 5 C or > 25 C	10	20	30	H	0.125	1.25	H
5.2	2	Improper sensory quality of the water source	salt, iron, pollutants	suppressed drinking, thirst, frustration, thermal discomfort	2	100	25	50	75	H	365	> 3000 ppm total dissolved solids	1	5	10	H	1.25	50	H
5.1	3	Poor feed quality (roughage)	Poor nutritive value, Improper sensory quality of feed	hunger, exhaustion	3	100	95	99	100	M	100	Ammonia, butiric acid levels	5	10	15	H	7.425	75	H
5.1	4	Improper ration composition (cf)	Inadequate fibre/carbohydrate ratio and fibre quality/lenght	behaviour disorders, reduced rumination	2	120	95	99	100	M	120	rumen pH < 5.5	30	35	40	H	20.79	60	H
5.1	5	Underfeeding	including inadequate nutrient supply in relation to genotype and energy output	chronic hunger, exhaustion, social stress	3	80	95	99	100	M	80	> BHB 1.2 mmol/l or change in BCS	10	25	40	M	14.85	60	M
5.1	6	Inadequate feeding schedule	frequency and regularity of supplying feed	inappetance, social stress	2	50	95	99	100	H	325	period of absence of feed >1 h	5	10	15	H	2.475	25	H

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

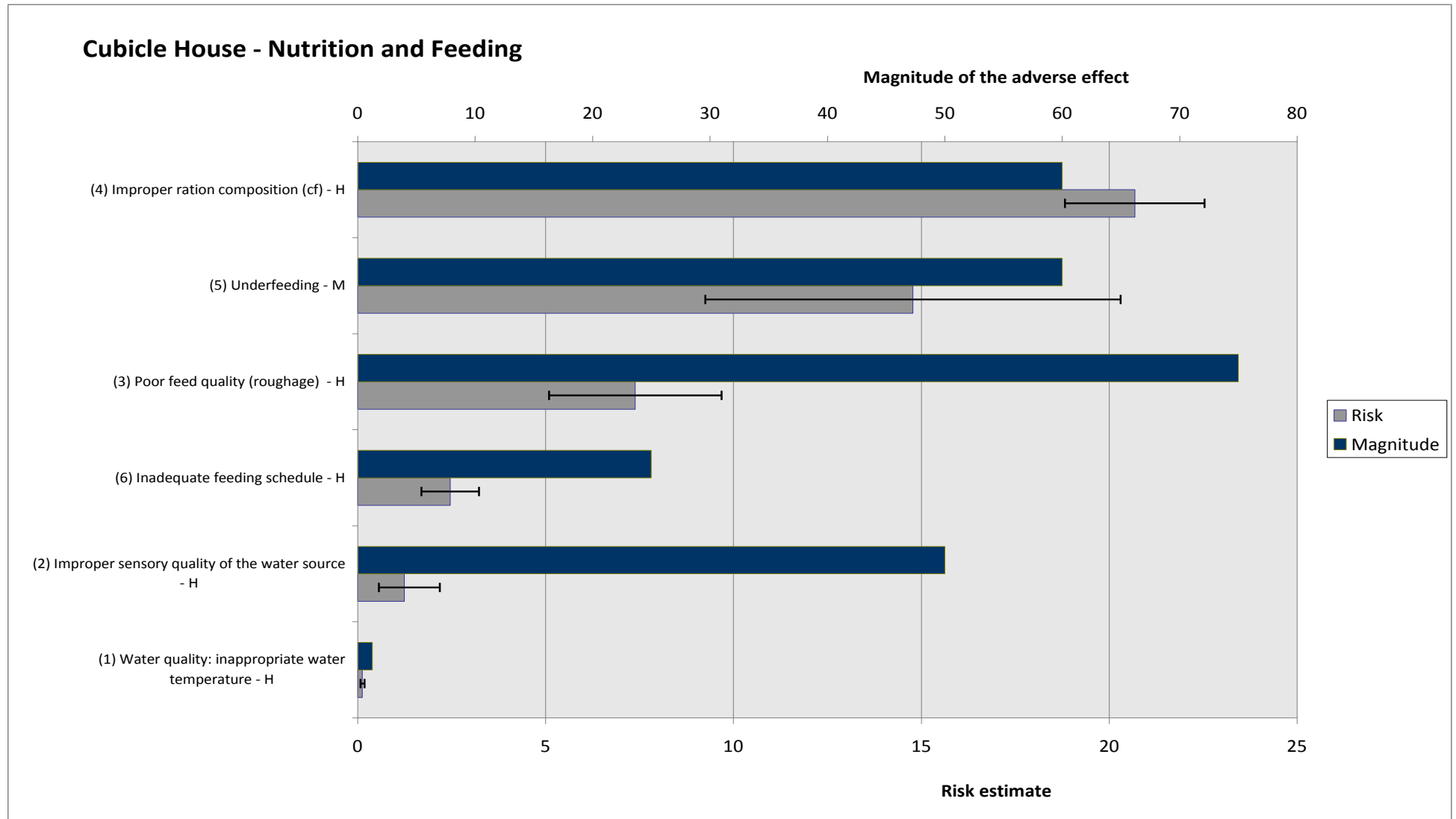


Figure 4. Ranking of hazards related to nutrition and feeding in dairy cows kept in cubicle houses.

CUBICLE HOUSES																			
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																			
8.2. / 8.3 / 8.4	1	Poor calving conditions	calving management	pain, social stress, fear	4	1	1	3	5	M	5	full exposure	50	60	70	H	0.018	1	H
3.3	2	Being tied up temporarily	Temporarily tied up (cow not used to)	behaviour abnormalities, frustration, inability to carry out maintenance behaviour, fear, pain	3	5	80	90	100	H	20	full exposure	1	5	10	H	0.16875	3.75	H
8.1	3	Mixing animals from different groups	the animal that is moved to another group	social disruption, pain, fear	3	21	80	90	100	M	3	full exposure	98	99	100	M	14.03325	15.75	M
8.1	4	Mixing animals from different groups (big farms: > 100 cows)	the group receiving new animals	social disruption, pain, fear	1	190	5	10	15	H	190	full exposure	60	70	80	M	3.325	47.5	H
8.1	5	Mixing animals from different groups (small farms < 100 cows)	the group receiving new animals	social disruption, pain, fear	1	30	10	20	30	H	30	full exposure	20	30	40	M	0.45	7.5	H
13.1	6	Insufficient or inappropriate contact with humans	--	fear	1	15	25	50	75	M	365	few or no positive contacts	20	30	40	H	0.5625	3.75	H
13.1	7	Insufficient or inappropriate contact with humans	--	fear, pain	3	15	90	95	100	L	365	high % of negative contacts	15	25	35	H	2.671875	11.25	H
12.3	8	Inadequate biosecurity	inadequate control of irritant insects	behaviour disruption	2	25	25	50	75	H	100	full exposure	30	50	70	H	3.125	12.5	H

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

CUBICLE HOUSES																			
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	9	Withholding necessary veterinary therapeutic health care / poor health care and welfare plan	e.g. claw trimmer	locomotion problems, pain	3	80	40	60	80	M	40	full exposure	20	30	40	H	10.8	60	H
13.8	10	Improper analgesia during surgery	Dehorning	pain	4	0.1	100	100	100	M	1	full exposure	1	5	10	H	0.005	0.1	H
13.8	11	Improper post-operational pain management	Dehorning	pain, behaviour disturbance	4	14	100	100	100	H	5	full exposure	5	10	15	H	1.4	14	H
13.4	12	being tail-docked	inadequate insect defence and neuroma formation	pain, behaviour disturbance	2	20	80	90	100	L	90	full exposure	1	5	10	H	0.45	10	H
13.8	13	Improper analgesia during surgery	Any surgery (e.g. caesarean, displaced abomasum)	pain, behaviour disturbance	4	0.1	100	100	100	H	3	full exposure	1	2	3	H	0.002	0.1	H
13.8	14	Improper post-operational pain management	Any surgery (e.g. caesarean, displaced abomasum)	pain, behaviour disturbance	4	7	100	100	100	H	10	full exposure	20	30	40	H	2.1	7	H
13.7	15	Improper management of "Downer cow"	Lack of physiotherapy, good bedding, proper facilities and lifting devices	pain, behaviour disturbance, fear, frustration	4	15	90	95	100	M	15	full exposure	5	15	25	H	2.1375	15	H
6.11	16	Use of electric goads	--	pain, fear, injuries, altered behaviour	3	20	80	90	100	M	0.5	full exposure	5	10	15	H	1.35	15	H

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

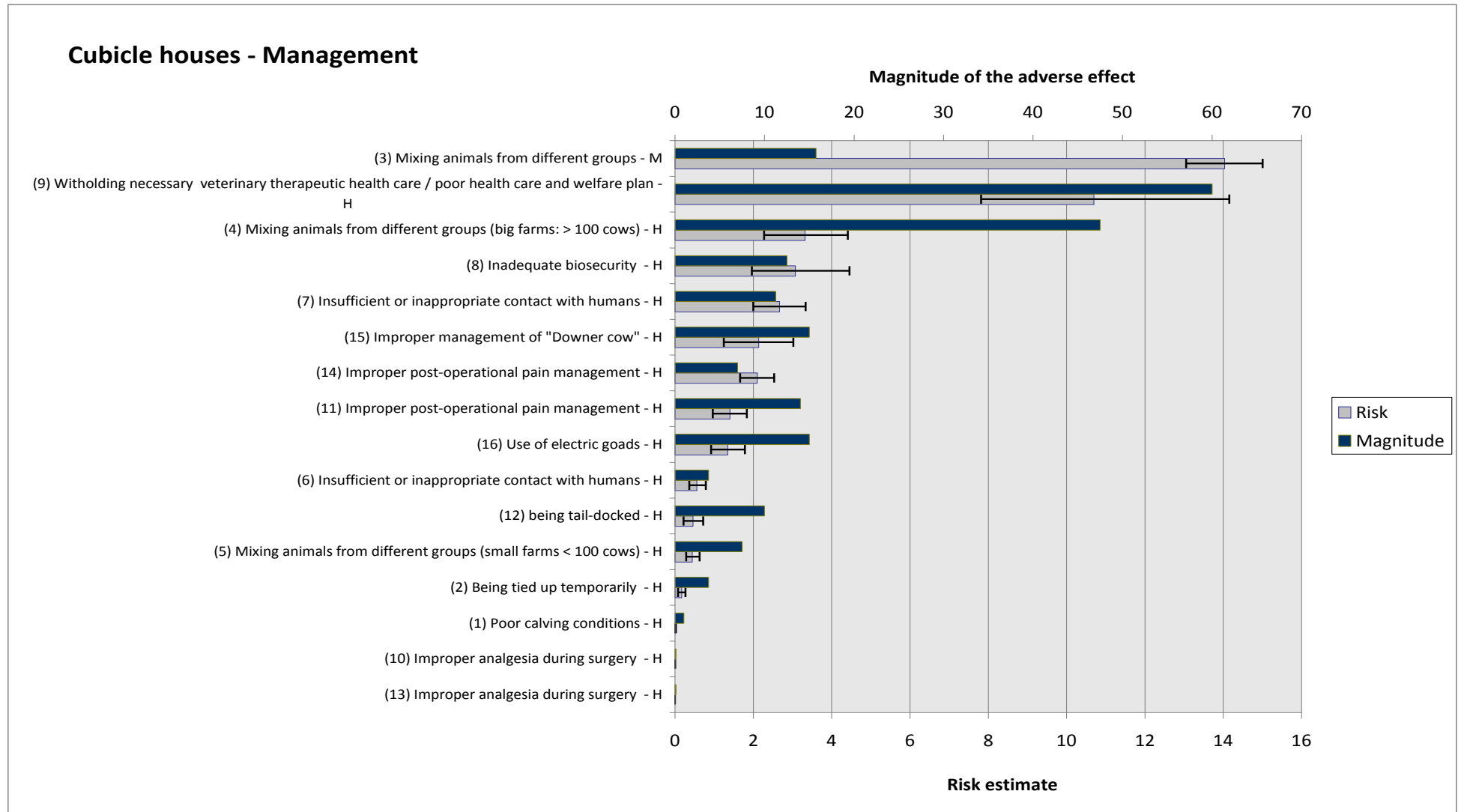


Figure 6. Ranking of hazards related to management in dairy cows kept in cubicle houses.

CUBICLE HOUSES																			
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	increased constraint on time available for activities	1	100	20	30	40	H	325	estimated breeding value for yield in top quartile for breed and country	20	30	40	H	2.25	25	H
4.2	2	high genetic potential for production due to selection ignoring other traits	without good housing, nutrition and management	increased constraint on time available for activities	2	150	30	40	50	H	325	estimated breeding value for yield in top quartile for breed and country	20	40	40	H	12	75	H
4.2	3	high genetic potential for production due to selection ignoring other traits	With twice a day milking	Discomfort as a result of full udder	2	50	70	80	90	H	325	estimated breeding value for yield in top quartile for breed and country	20	30	40	H	6	25	H

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

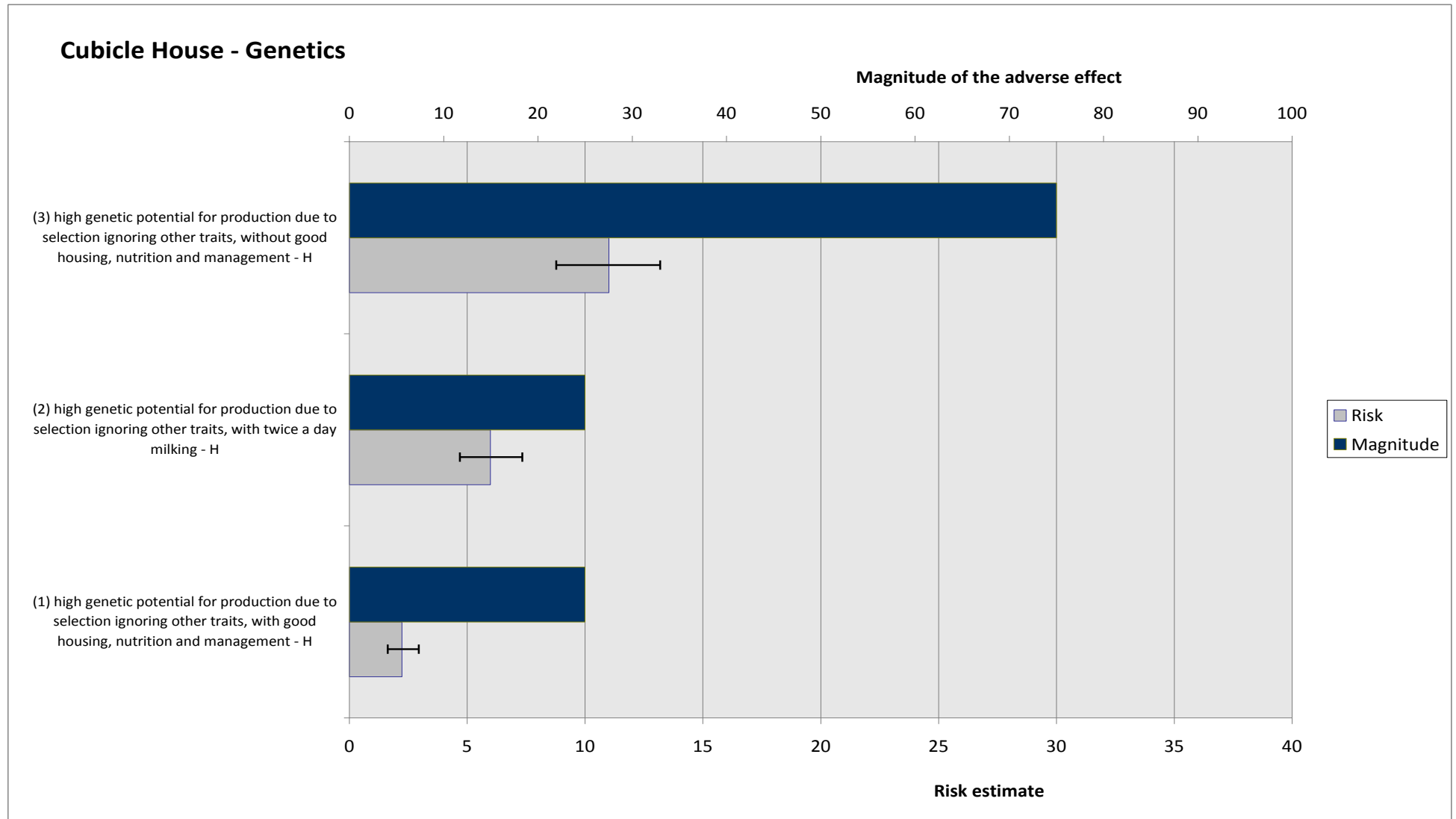


Figure 8. Ranking of hazards related to genetics in dairy cows kept in cubicle houses.

TIE-STALLS																Risk Characterization			
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 (with aspects of management)																			
6.5.	1	Insufficient light level (day/night)	too dark (for both cows and stockperson)	inability to carry out normal behaviour	1	22	99	99.5	100	H	45	< 40 lux	5	10	15	M	0.54725	5.5	H
6.5.	2	light duration	too short	inability to carry out normal behaviour	1	30	99	99.5	100	H	60	< 6 h	15	30	50	M	2.23875	7.5	H
6.5.	3	light duration	too long	too little rest	1	90	10	20.0	30	H	365	> 18 h	1	3	5	M	0.135	22.5	H
5.1 / 6.1	4	inadequate feeding installation	--	behaviour disruption and prevention, pain	3	90	99	99.5	100	M	365	full exposure	10	20	30	M	13.4325	67.5	M
6.1	5	Poor stall design	including too small stalls	too little rest, behaviour disruption and prevention, pain, fear	3	365	70	80	90	L	365	full exposure	40	70	90	L	153.3	273.75	L
6.7	6	Inadequate bedding	--	too little rest, behaviour disruption and prevention, pain, thermal discomfort, fear	3	365	70	80	90	L	365	full exposure	30	50	70	M	109.5	273.75	M
6.1	7	Inadequate floor (limited to passage ways, feeding and milking areas)	too slippery, too hard, injuring, too rough	locomotion, injuries, claw and leg disorders, maintenance behaviour, reproduction	3	52	99	99.5	100	M	365	full exposure	50	70	100	M	27.1635	39	M

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

TIE-STALLS																			
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 (with aspects of management)																			
3.3	8	Being tied without exercise (zero-grazing)	Insufficient opportunity for exercising and social interactions, poor maintenance behaviour, disturbed rest	locomotion problems, behaviour disruption, frustration, social stress	3	365	99	99.5	100	M	365	Zero-grazing (see also chapter 11.8)	25	50	75	H	136.19063	273.75	H
3.3	9	Being tied on average 9 months without exercise (3 months of grazing)	Insufficient opportunity for exercising and social interactions, poor maintenance behaviour, disturbed rest	locomotion problems, behaviour disruption, frustration, social stress,	3	270	99	99.5	100	M	270	3 months of grazing (see also chapter 11.8)	25	50	75	H	100.74375	202.5	H
5.2	10	Insufficient access to water	inappropriate system design	temporary thirst, social stress, frustration, behaviour disruption	2	72	40	50	60	M	365	more than 5 hours water deprivation	5	10	15	H	1.8	36	H
5.2	11	Insufficient access to water	Broken system, poor management	thirst, social stress, frustration, behaviour disruption	3	0.5	99	99.5	100	M	1	total lack of water	0	0.1	0.2	H	0.0003731	0.375	H
13.1	12	Inadequate or lack of handling/restraining facilities	---	behaviour disruption and prevention, pain, fear	2	20	60	80	100	H	10	full exposure	30	50	70	H	4	10	H
6.11	13	Use of cow trainers	Zero-grazing	stress, fear, pain, disrupted behaviour	2	180	80	90	100	M	365	full exposure	15	25	35	H	20.25	90	H
6.11	14	Use of cow trainers	4 months at pasture	stress, fear, pain, disrupted behaviour	2	125	80	90	100	M	240	full exposure	15	25	35	H	14.0625	62.5	H
6.11	15	Inadequate design of waiting area	size, flooring, crowding gates	behaviour disruption and prevention, pain, fear	2	32	50	65	80	M	325	full exposure	15	30	45	H	3.12	16	H

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

TIE-STALLS																			
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 (with aspects of management)																			
7.2 / 7.3	16	Inadequate milking parlour design	--	behaviour disruption and prevention, pain, fear, frustration	2	16	50	65	80	H	325	full exposure	5	10	15	H	0.52	8	H
7.2 / 7.3	17	Inadequate maintenance of milking equipment	--	pain, fear, frustration	3	16	99	99.5	100	L	60	full exposure	20	30	40	H	3.582	12	H
6.5	18	Inappropriate temperature, humidity	--	thermal discomfort	2	25	50	60	70	M	30	75<THI<78	50	60	70	H	4.5	12.5	H
6.5	19	Inappropriate temperature, humidity	--	thermal discomfort	3	15	60	70	80	L	15	78<THI<83	40	50	60	H	3.9375	11.25	H
6.5	20	Inappropriate temperature, humidity	--	thermal discomfort	4	10	90	95	100	L	5	THI>83	10	15	20	H	1.425	10	H
6.5	21	Poor air quality (cows with access to pasture)	too high ammonia, bioaerosols and dust	Pain and discomfort	3	60	99	100	100	M	60	inadequate	1	6	10	H	2.7	45	H
6.5	22	Poor air quality (cows kept permanently indoors)	too high ammonia, bioaerosols and dust	Pain and discomfort	3	200	99	100	100	M	200	inadequate	1	6	10	H	9	150	H

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

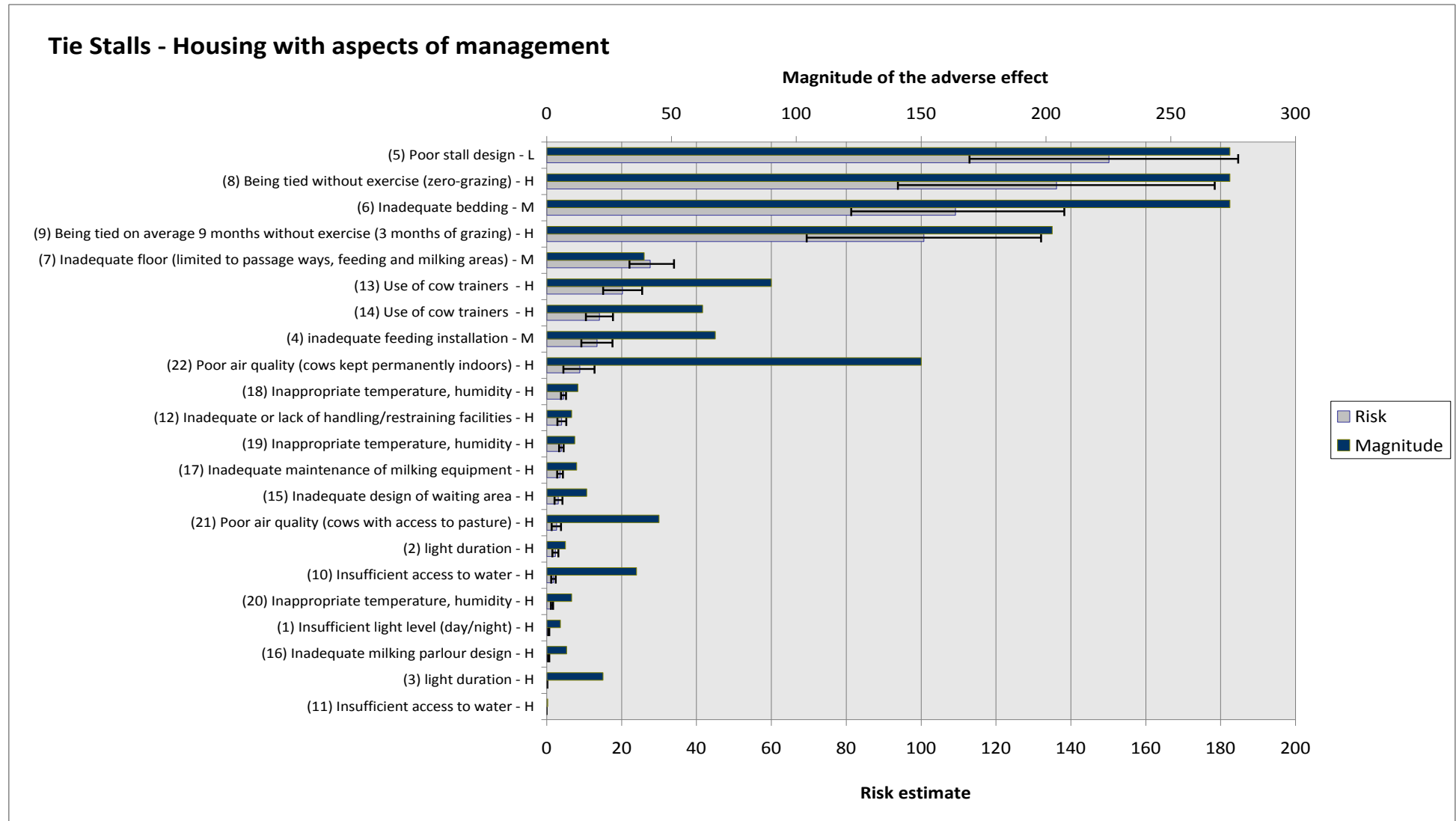


Figure 10. Ranking of hazards related to housing in dairy cows kept in tie stalls.

TIE-STALLS																			
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																			
5.2	1	Water quality: inappropriate water temperature	too high or too low	thirst, frustration, thermal discomfort	1	5	25	50	75	H	60	< 5 C or > 25 C	10	20	30	H	0.125	1.25	H
5.2	2	Improper sensory quality of the water source	salt, iron, pollutants	suppressed drinking, thirst, frustration, thermal discomfort	2	100	25	50	75	H	365	> 3000 ppm total dissolved solids	1	5	10	H	1.25	50	H
5.1	3	Poor feed quality (roughage)	Poor nutritive value, Improper sensory quality of feed	hunger, exhaustion	3	100	95	99	100	M	100	Ammonia, butiric acid levels	5	10	15	H	7.425	75	H
5.1	4	Improper ration composition (cf)	Inadequate fibre/carbohydrate ratio and fibre quality/lenght	behaviour disorders, reduced rumination	2	120	95	99	100	M	120	rumen pH < 5.5	30	35	40	H	20.79	60	H
5.1	5	Underfeeding	including inadequate nutrient supply in relation to genotype and energy output	chronic hunger, exhaustion, social stress	3	80	95	99	100	M	80	> BHB 1.2 mmol/l or change in BCS	10	25	40	M	14.85	60	M
5.1	6	Inadequate feeding schedule	frequency and regularity of supplying feed	inappetance, social stress	2	50	95	99	100	H	325	period of absence of feed >1 h	5	10	15	H	2.475	25	H

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

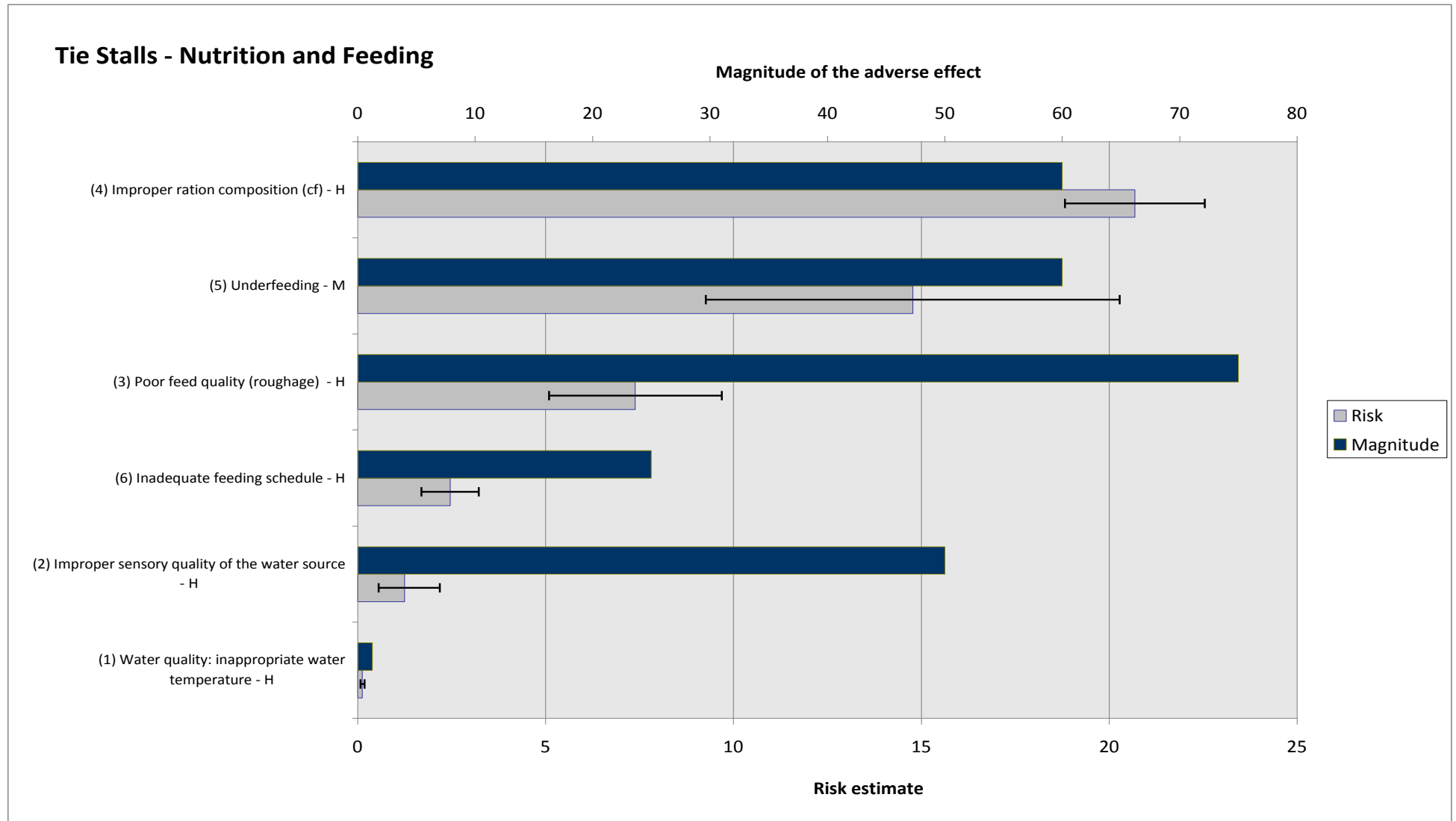


Figure 12. Ranking of hazards related to nutrition and feeding in dairy cows kept in tie stalls.

TIE-STALLS																			
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																			
8.2. / 8.3 / 8.4	1	Poor calving conditions	calving management	pain, social stress, fear	4	1	1	3	5	M	5	full exposure	50	60	70	H	0.018	1	H
13.1	2	Insufficient or inappropriate contact with humans	--	fear	1	15	25	50	75	M	365	few or no positive contact	20	30	40	H	0.5625	3.75	H
13.1	3	Insufficient or inappropriate contact with humans	--	fear, pain	3	15	90	95	100	L	365	high % of negative contact	15	25	35	H	2.671875	11.25	H
12.3	4	Inadequate biosecurity	inadequate control of irritant insects	behaviour disruption	2	25	25	50	75	H	100	full exposure	30	50	70	H	3.125	12.5	H
13.1	5	Withholding necessary veterinary therapeutic health care / poor health care and welfare plan	e.g. claw trimmer	locomotion problems, pain	3	80	40	60	80	M	40	full exposure	20	30	40	H	10.8	60	H
13.8	6	Improper analgesia during surgery	Dehorning	pain	4	0.1	100	100	100	M	1	full exposure	1	5	10	H	0.005	0.1	H

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

TIE-STALLS																			
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																			
13.8	7	Improper post-operational pain management	Dehorning	pain, behaviour disturbance	4	14	100	100	100	H	5	full exposure	5	10	15	H	1.4	14	H
13.4	8	being tail-docked	inadequate insect defence and neuroma formation	pain, behaviour disturbance	2	20	80	90	100	L	90	full exposure	1	5	10	H	0.45	10	H
13.8	9	Improper analgesia during surgery	Any surgery (e.g. caesarean, displaced abomasum)	pain, behaviour disturbance	4	0.1	100	100	100	H	3	full exposure	1	2	3	H	0.002	0.1	H
13.8	10	Improper post-operational pain management	Any surgery (e.g. caesarean, displaced abomasum)	pain, behaviour disturbance	4	7	100	100	100	H	10	full exposure	20	30	40	H	2.1	7	H
13.7	11	Improper management of "Downer cow"	Lack of physiotherapy, good bedding, proper facilities and lifting devices	pain, behaviour disturbance, fear, frustration	4	15	90	95	100	H	15	full exposure	5	15	25	H	2.1375	15	H
6.11	12	Use of electric goads	--	pain, fear, injuries, altered behaviour	3	20	80	90	100	M	0.5	full exposure	5	10	15	H	1.35	15	H

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

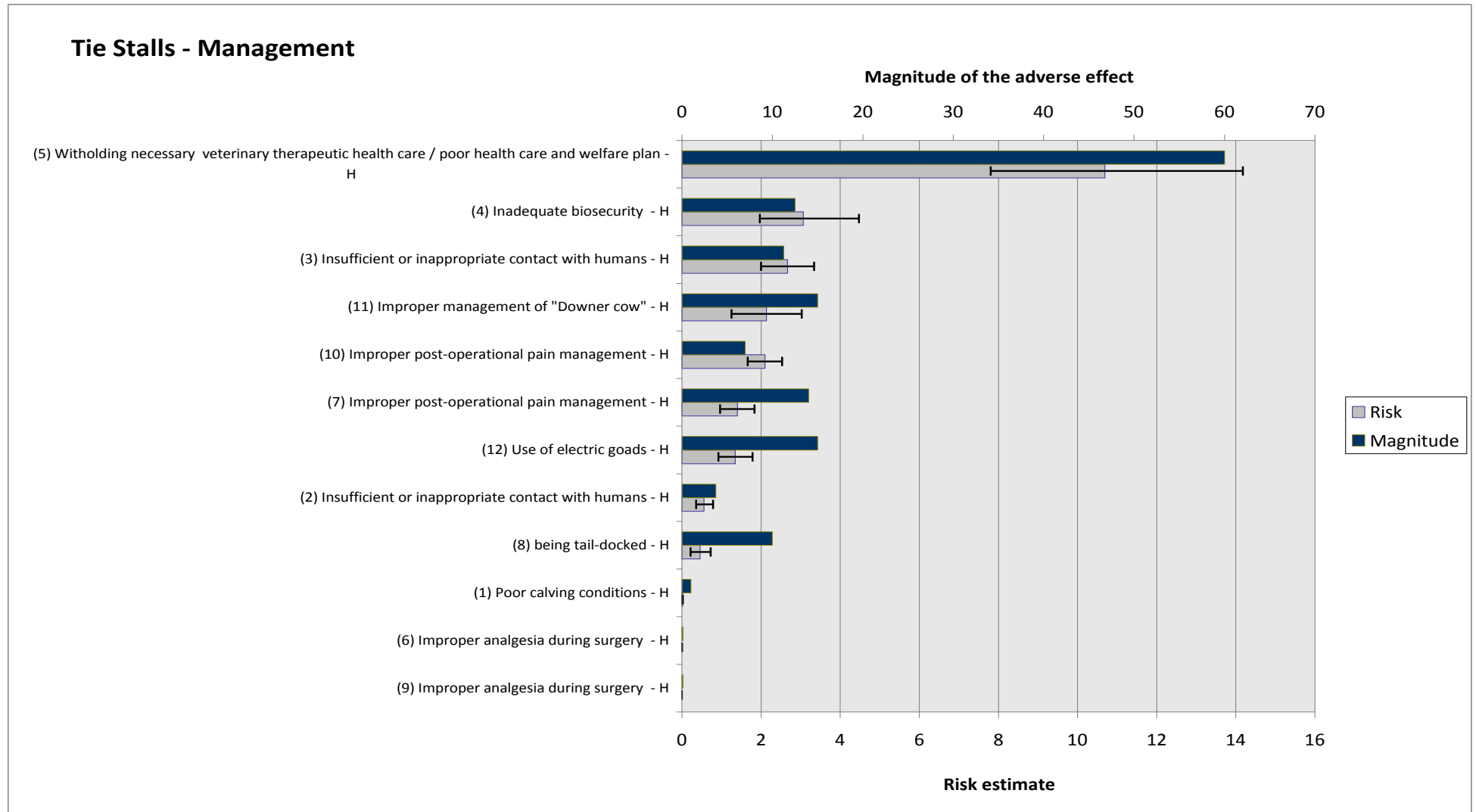


Figure 14. Ranking of hazards related to management in dairy cows kept in tie stalls.

TIE-STALLS																			
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	increased constraint on time available for activities	1	100	20	30	40	H	325	estimated breeding value for yield in top quartile for breed and country	20	30	40	H	2.25	25	H
4.2	2	high genetic potential for production due to selection ignoring other traits	without good housing, nutrition and management	increased constraint on time available for activities	2	150	30	40	50	H	325	estimated breeding value for yield in top quartile for breed and country	30	40	50	H	12	75	
4.2	3	high genetic potential for production due to selection ignoring other traits	With twice a day milking	Discomfort as a result of full udder	2	50	70	80	90	H	325	estimated breeding value for yield in top quartile for breed and country	20	30	40	H	6	25	H

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

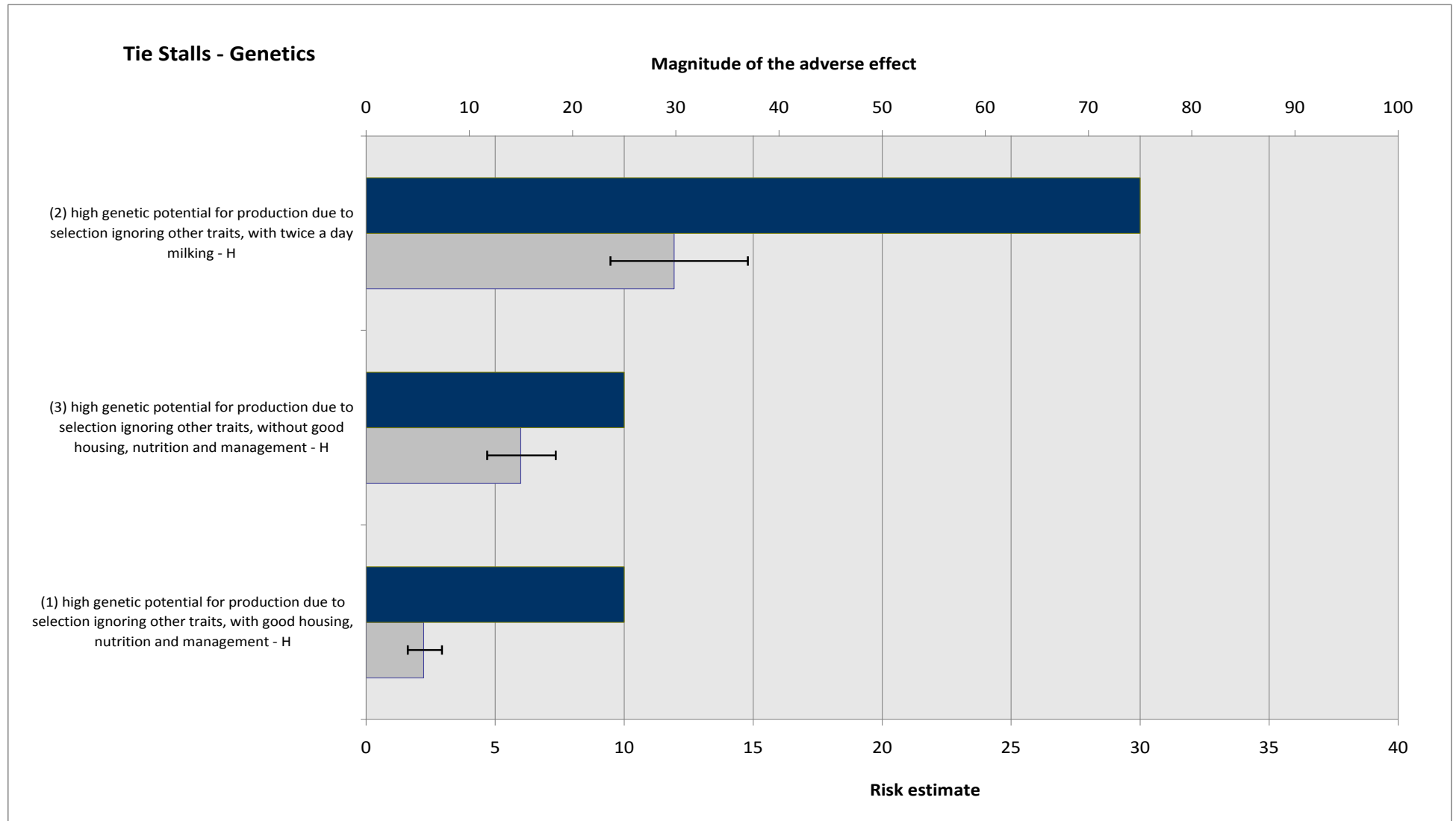


Figure 16. Ranking of hazards related to genetics in dairy cows kept in tie stalls.

STRAW YARDS																			
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 (with aspects of management)																			
6.5.	1	Insufficient light level (day/night)	too dark (for both cows and stockperson)	inability to carry out normal behaviour	1	22	99	99.5	100	H	45	< 40 lux	5	10	15	M	0.55	5.5	H
6.5.	2	light duration	too short	inability to carry out normal behaviour	1	30	99	99.5	100	H	60	< 6 h	15	30	50	M	2.24	7.5	H
6.5.	3	light duration	too long	too little rest	1	90	10	20.0	30	H	365	> 18 h	1	3	5	M	0.14	22.5	H
5.1 / 6.1	4	inadequate feeding installation	--	behaviour disruption and prevention, pain	3	90	99	99.5	100	M	365	full exposure	10	20	30	M	13.43	67.5	M
6.7	5	Inadequate bedding	Bedding too wet and dirty	too little rest, behaviour disruption and prevention, pain, thermal discomfort, fear	2	182	70	80	90	M	365	full exposure	10	20	30	M	14.56	91	M
6.1	6	Inadequate floor (limited to passage ways, feeding and milking areas)	too slippery, too hard, injuring, too rough	fear of slipping and falling, inhibited maintenance and social behaviour, pain	2	40	99	99.5	100	M	365	full exposure	30	50	70	M	9.95	20	M

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

STRAW YARDS																			
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 (with aspects of management)																			
6.2	7	Lack of space, e.g. for exercising, social interactions and resting	--	locomotion problems, behaviour disruption, social stress, too little rest	2	182	25	50	75	H	365	full exposure	20	30	40	H	13.65	91	H
5.2	8	Insufficient access to water	inappropriate system design	temporary thirst, social stress, frustration, behaviour disruption	2	72	40	50	60	M	365	more than 5 hours water deprivation	5	10	15	H	1.80	36	H
5.2	9	Insufficient access to water	Broken system, poor management	thirst, social stress, frustration, behaviour disruption	3	0.5	99	99.5	100	M	1	total lack of water	0	0.1	0.2	H	0.00	0.375	H
13.1	10	Inadequate or lack of handling/restraining facilities	--	behaviour disruption and prevention, pain, fear	2	20	60	80	100	H	10	full exposure	30	50	70	H	4.00	10	H
6.1	11	Inadequate design of waiting area	size, flooring, crowding gates	behaviour disruption and prevention, pain, fear	2	32	50	65	80	H	325	full exposure	15	30	45	H	3.12	16	H

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

STRAW YARDS																			
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 (with aspects of management)																			
7.2 / 7.3	12	Inadequate milking parlour design		behaviour disruption and prevention, pain, fear, frustration	2	16	50	65	80	H	325	full exposure	5	10	15	H	0.52	8	H
7.2 / 7.3	13	Inadequate maintenance of milking equipment		pain, fear, frustration	3	16	99	99.5	100	L	60	full exposure	20	30	40	H	3.582	12	H
6.5	14	Inappropriate temperature, humidity	too hot and humid	thermal discomfort	2	25	50	60	70	M	30	75<THI<78	50	60	70	H	4.5	12.5	H
6.5	15	Inappropriate temperature, humidity	too hot and humid	thermal discomfort	3	15	60	70	80	L	15	78<THI<83	40	50	60	H	3.9375	11.25	H
6.5	16	Inappropriate temperature, humidity	too hot and humid	thermal discomfort	4	10	90	95	100	L	5	THI>83	10	15	20	H	1.425	10	H
8.2	17	Poor calving conditions	absence of pen, pen design, facilities (inability to separate from other animals)	social stress, fear, pain, behavioural disruption	2	3.5	40	50	60	M	7	full exposure	30	50	70	H	0.44	1.75	H
6.1	18	too few feeding places in zero grazing systems	--	social stress, hunger, frustration, behaviour disruption	3	90	5	10	20	M	365	> 1 cow per place	15	30	40	H	2.025	67.5	H
3.2 / 6.8	19	zero-grazing with access to outdoors	--	social stress, behaviour disruption and prevention	2	162	0	40	80	H	325	full exposure	10	20	30	H	6.48	81	H
3.2 / 6.8	20	zero-grazing without access to outdoors	--	social stress, behaviour disruption and prevention	2	182	0	50	100	H	365	full exposure	15	20	25	H	9.1	91	H

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

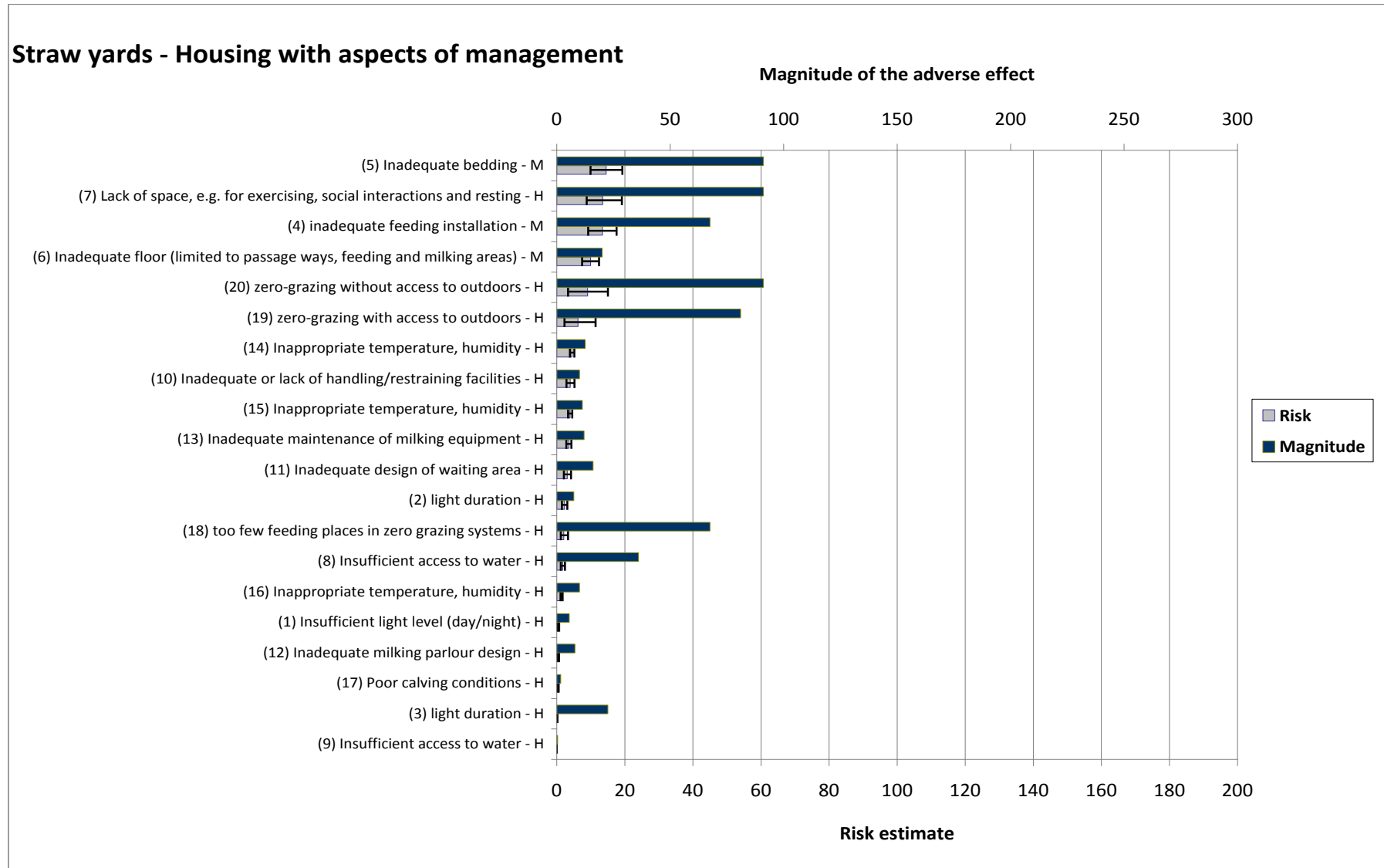


Figure 18. Ranking of hazards related to housing in dairy cows kept in straw yards.

STRAW YARDS																			
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																			
5.2	1	Water quality: inappropriate water temperature	too high or too low	thirst, disease, frustration, thermal discomfort	1	5	25	50	75	H	60	< 5 C or > 25 C	10	20	30	H	0.125	1.25	H
5.2	2	Improper sensory quality of the water source	salt, iron, pollutants	suppressed drinking, thirst, frustration, thermal discomfort	2	100	25	50	75	H	365	> 3000 ppm total dissolved solids	1	5	10	H	1.25	50	H
5.1	3	Poor feed quality (roughage)	Poor nutritive value, Improper sensory quality of feed	hunger, exhaustion	3	100	95	99	100	M	100	Ammonia, butiric acid levels	5	10	15	H	7.425	75	H
5.1	4	Improper ration composition (cf)	Inadequate fibre/carbohydrate ratio and fibre quality/lenght	behaviour disorders, reduced rumination	2	120	95	99	100	M	120	rumen pH < 5.5	1	5	10	H	2.97	60	H
5.1	5	Underfeeding	including inadequate nutrient supply in relation to genotype and energy output	chronic hunger, exhaustion, social stress	3	80	95	99	100	M	80	> BHB 1.2 mmol/l or change in BCS	10	25	40	M	14.85	60	M
5.1	6	Inadequate feeding schedule	frequency and regularity of supplying feed	inappetance, social stress	2	50	95	99	100	H	325	period of absence of feed >1 h	5	10	15	H	2.475	25	H

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

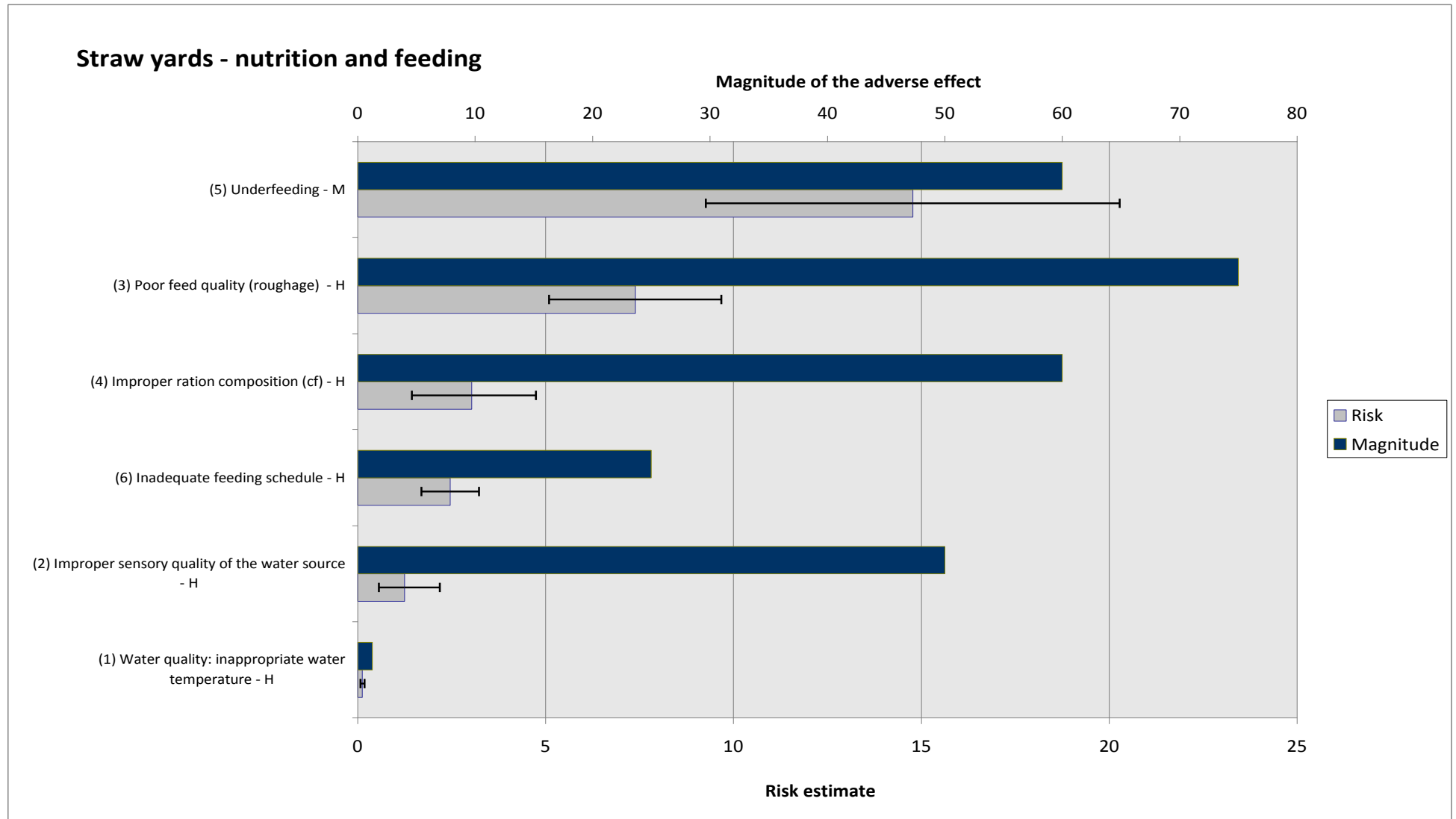


Figure 20. Ranking of hazards related to nutrition and feeding in dairy cows kept in straw yards.

STRAW YARDS																			
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	m	max				min	m	max				
MANAGEMENT																			
7.2. / 7.3 / 7.4	1	Poor calving conditions	calving management	pain, social stress, fear	4	1	1	3	5	M	5	full exposure	50	60	70	H	0.018	1	H
3.3	2	Being tied up temporarily	--	behaviour abnormalities, frustration, inability to carry out maintenance	3	5	80	90	100	H	20	full exposure	1	5	10	H	0.16875	3.75	H
8.1	3	Mixing animals from different groups (big farms: > 100 cows)	the group receiving new animals	social disruption, pain, fear	1	190	5	10	15	H	190	full exposure	60	70	80	M	3.325	47.5	H
8.1	4	Mixing animals from different groups (small farms < 100 cows)	the group receiving new animals	social disruption, pain, fear	1	30	10	20	30	H	30	full exposure	20	30	40	M	0.45	7.5	H
13.1	5	Insufficient or inappropriate contact with humans	--	fear	1	15	25	50	75	M	365	few or no positive contact	20	30	40	H	0.5625	3.75	H
13.1	6	Insufficient or inappropriate contact with humans	--	fear, pain	3	15	90	95	100	L	365	high % of negative contact	15	25	35	H	2.671875	11.25	H
12.3	7	Inadequate biosecurity	inadequate control of irritant insects	behaviour disruption	2	25	25	50	75	H	100	full exposure	30	50	70	H	3.125	12.5	H
13.1	8	Withholding necessary veterinary therapeutic health care / poor health care and welfare plan	e.g. claw trimmer	locomotion problems, pain	3	80	40	60	80	M	40	full exposure	20	30	40	H	10.8	60	H

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

STRAW YARDS																			
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	m	max				min	m	max				
MANAGEMENT																			
13.8	9	Improper analgesia during surgery	Dehorning	pain	4	0.1	100	100	100	M	1	full exposure	1	5	10	H	0.005	0.1	H
13.8	10	Improper post-operational pain management	Dehorning	pain, behaviour disturbance	4	14	100	100	100	H	5	full exposure	5	10	15	H	1.4	14	H
13.4	11	being tail-docked	inadequate insect defence and neuroma formation	pain, behaviour disturbance	2	20	80	90	100	L	90	full exposure	1	5	10	H	0.45	10	H
13.8	12	Improper analgesia during surgery	Any surgery (e.g. caesarean, displaced abomasum)	pain, behaviour disturbance	4	0.1	100	100	100	H	3	full exposure	1	2	3	H	0.002	0.1	H
13.8	13	Improper post-operational pain management	Any surgery (e.g. caesarean, displaced abomasum)	pain, behaviour disturbance	4	7	100	100	100	H	10	full exposure	20	30	40	H	2.1	7	H
13.7	14	Improper management of "Downer cow"	Lack of physiotherapy, good bedding, proper facilities and lifting devices	pain, behaviour disturbance, fear, frustration	4	15	90	95	100	M	15	full exposure	5	15	25	H	2.1375	15	H
6.11	15	Use of electric goods	--	pain, fear, injuries, altered behaviour	3	20	80	90	100	M	0.5	full exposure	5	10	15	H	1.35	15	H

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

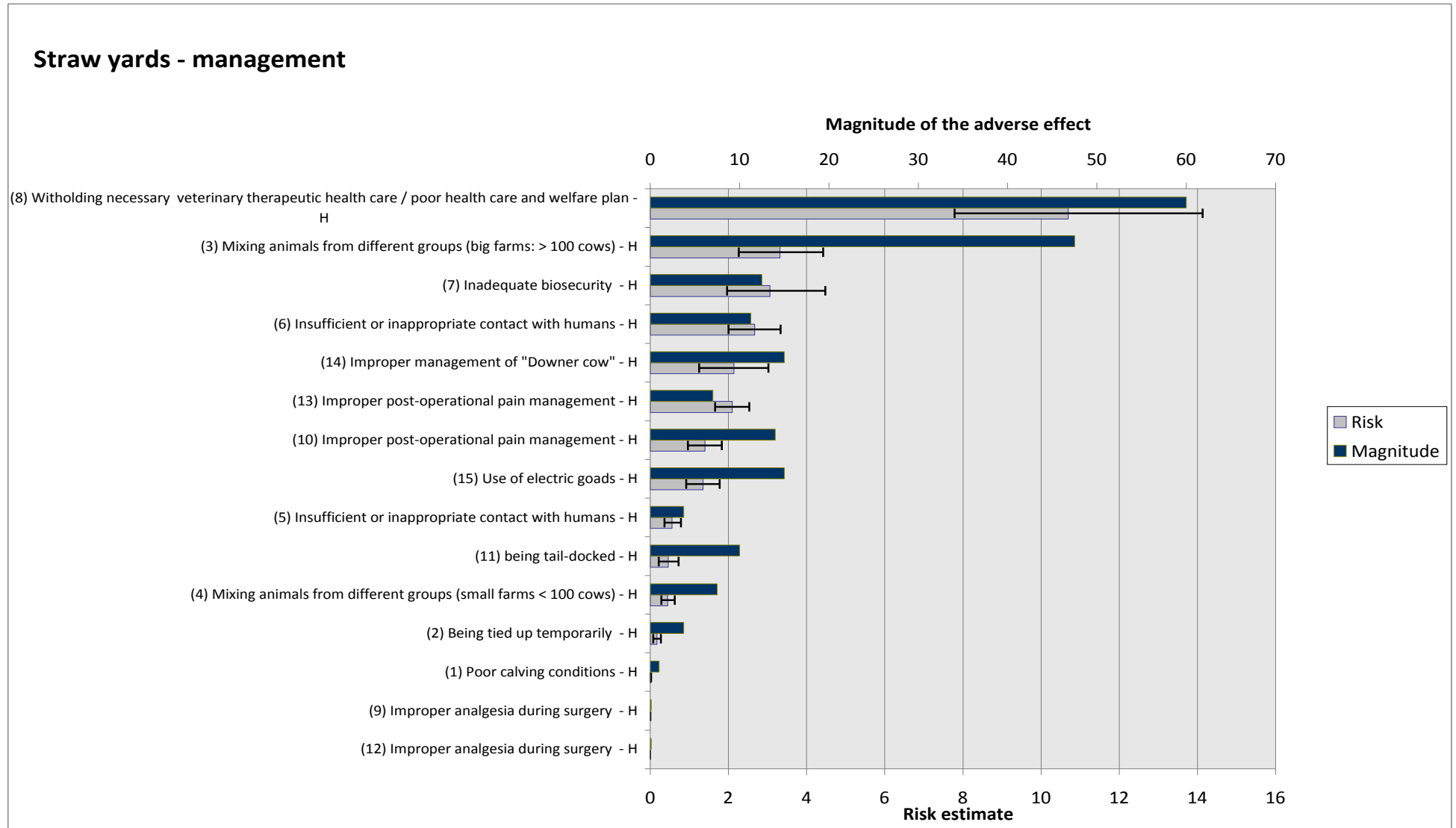


Figure 22. Ranking of hazards related to management in dairy cows kept in straw yards.

STRAW YARDS																			
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	increased constraint on time available for activities	1	100	20	30	40	H	325	estimated breeding value for yield in top quartile for breed and country	20	30	40	H	2.25	25	H
4.2	2	high genetic potential for production due to selection ignoring other traits	without good housing, nutrition and management	increased constraint on time available for activities	2	150	30	40	50	H	325	estimated breeding value for yield in top quartile for breed and country	30	40	50	H	12	75	H
4.2	3	high genetic potential for production due to selection ignoring other traits	With twice a day milking	Discomfort as a result of full udder	2	60	70	80	90	H	325	estimated breeding value for yield in top quartile for breed and country	20	30	40	H	7.2	30	H

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

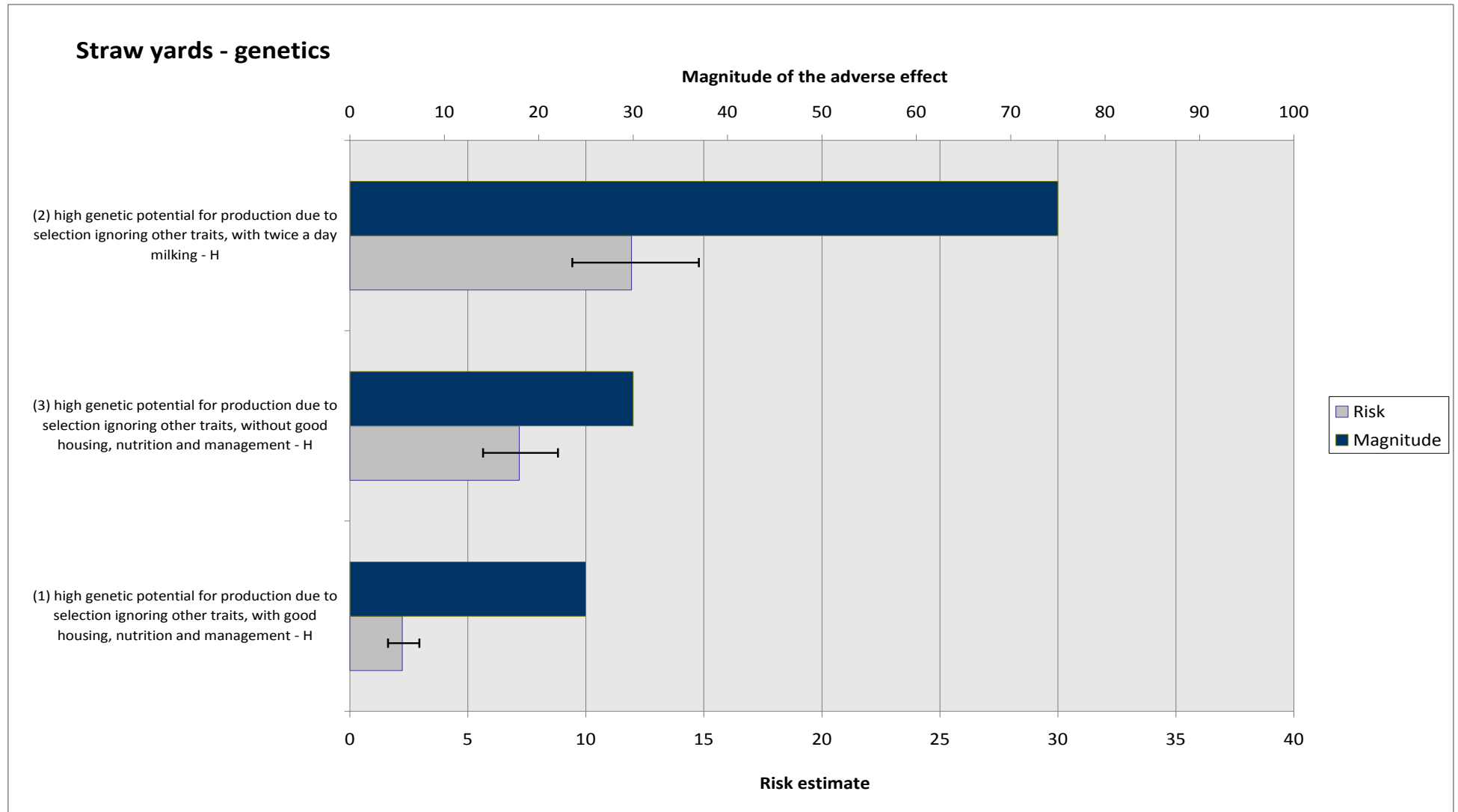


Figure 24. Ranking of hazards related to genetics in dairy cows kept in straw yards.

PASTURE																			
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 (with aspects of management)																			
6.1	1	Walking tracks too long, or poorly maintained	pathways uneven, stony, too slippery or too hard	fear, pain	2	10	99	99.5	100	H	180	> 0.5 Km	5	15	25	M	0.74625	5	H
5.2	2	Insufficient access to water	inappropriate system design	temporary thirst, social stress, frustration, behaviour disruption	2	40	40	50	60	M	182	more than 5 hours water deprivation	20	25	30	H	2.5	20	H
5.2	3	Insufficient access to water	broken system, poor management	thirst, social stress, frustration, behaviour disruption	2	0.5	99	99.5	100	M	1	total lack of water	0	0.1	0.2	H	0.0002488	0.25	H
13.1	4	Inadequate or lack of handling/restraining facilities	--	behaviour disruption and prevention, pain, fear	2	20	60	80	100	H	10	full exposure	30	50	70	H	4	10	H
6.1	5	Inadequate design of waiting area	--	behaviour disruption and prevention, pain, fear	2	32	50	65	80	H	325	full exposure	15	30	45	H	3.12	16	H

Figure 25. Risk assessment hazards related to housing (intended as environment) in dairy cows kept in pasture.

PASTURE																
Chapter of the scient. report	Hazard identification			Hazard characterization							Exposure assessment					
	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
							min	ml	max				min	ml	max	
	HOUSING (with aspects of management)															
7.2 / 7.3	6	Inadequate milking parlour design	--	behaviour disruption and prevention, pain, fear, frustration	2	16	50	65	80	H	325	full exposure	5	10	15	H
7.2 / 7.3	7	Inadequate maintenance of milking equipment	--	pain, fear, frustration	3	16	99	99.5	100	L	60	full exposure	20	30	40	H
6.5	8	Inappropriate temperature, humidity	--	thermal discomfort	2	25	50	60	70	M	30	75<THI<78	50	60	70	H
6.5	9	Inappropriate temperature, humidity	--	thermal discomfort	3	15	60	70	80	L	15	78<THI<83	40	50	60	H
6.5	10	Inappropriate temperature, humidity	--	thermal discomfort	4	10	90	95	100	L	5	THI>83	10	15	20	H
7.2	11	Poor calving conditions	Inability to separate from other animals	social stress, fear, pain, behavioural disruption	1	1	40	50	60	M	7	full exposure	40	50	60	H

Figure 25. Risk assessment hazards related to housing (intended as environment) in dairy cows kept in pasture (continued).

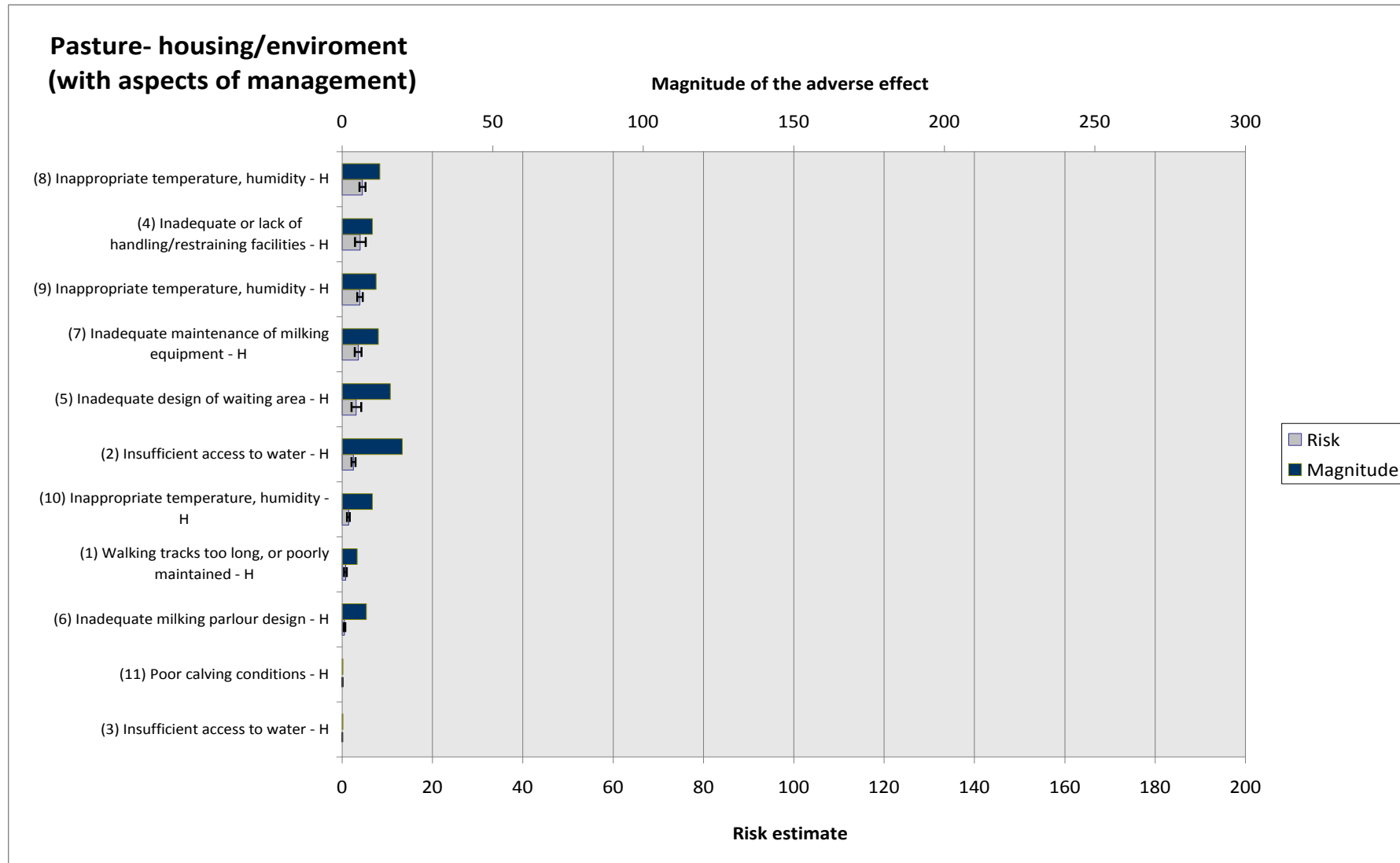


Figure 26. Ranking of hazards related to housing (intended as environment) in dairy cows kept in pasture.

PASTURE																			
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																			
5.2	1	Water quality: inappropriate water temperature	too high or too low	thirst, disease, frustration, thermal discomfort	1	5	25	50	75	H	60	< 5 C or > 25 C	25	30	35	H	0.1875	1.25	H
5.2	2	Improper sensory quality of the water source	salt, iron, pollutants	suppressed drinking, thirst, frustration, thermal discomfort	2	100	25	50	75	H	365	> 3000 ppm total dissolved solids	1	5	10	H	1.25	50	H
5.1	3	Underfeeding	including inadequate nutrient supply in relation to genotype and energy output	chronic hunger, exhaustion, social stress	3	80	95	99	100	M	80	> BHB 1.2 mmol/l or change in BCS	10	25	40	M	14.85	60	M

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

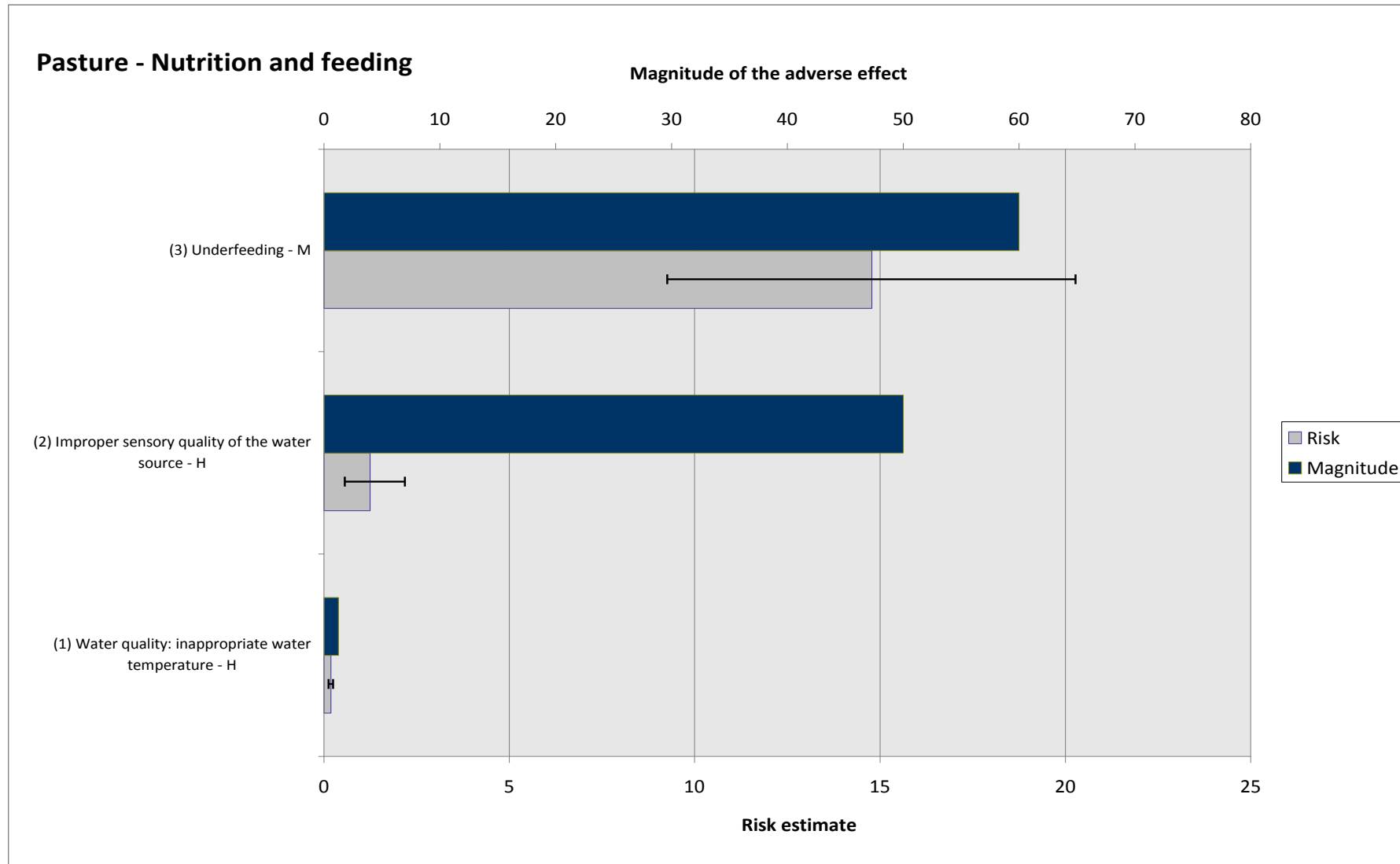


Figure 28. Ranking of hazards related to nutrition and feeding in dairy cows kept in pasture.

PASTURE																			
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	mI	max				min	mI	max				
MANAGEMENT																			
8.2. / 8.3 / 8.4	1	Poor calving conditions	calving management	pain, social stress, fear	4	1	1	3	5	M	5	full exposure	50	60	70	H	0.018	1	H
8.1	2	Mixing animals from different groups	the single animal is moved to another group	social disruption, pain, fear	2	21	80	90	100	M	5	full exposure	98	99	100	M	9.3555	10.5	M
8.1	3	Mixing animals from different groups (big farms: > 100 cows)	the group receiving new animals	social disruption, pain, fear	1	190	1	5	10	H	190	full exposure	60	70	80	M	1.6625	47.5	H
8.1	4	Mixing animals from different groups (small farms < 100 cows)	the group receiving new animals	social disruption, pain, fear	1	30	2	10	20	H	30	full exposure	20	30	40	M	0.225	7.5	H
13.1	5	Insufficient or inappropriate contact with humans	--	fear	1	15	25	50	75	M	365	few or no positive contact	20	30	40	H	0.5625	3.75	H
13.1	6	Insufficient or inappropriate contact with humans	--	fear, pain	3	15	90	95	100	L	365	high % of negative contact	15	25	35	H	2.671875	11.25	H
13.8	7	Improper analgesia during surgery	Dehorning	pain	4	0.1	100	100	100	M	1	full exposure	1	5	10	H	0.005	0.1	H

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

PASTURE																			
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																			
13.8	8	Improper post-operational pain management	Dehorning	pain, behaviour disturbance	4	14	100	100	100	H	5	full exposure	5	10	15	H	1.4	14	H
13.4	9	being tail-docked	inadequate insect defence and neuroma formation	pain, behaviour disturbance	2	20	80	90	100	L	90	full exposure	1	5	10	H	0.45	10	H
13.8	10	Improper analgesia during surgery	Any surgery (e.g. caesarean, displaced abomasum)	pain, behaviour disturbance	4	0.1	100	100	100	H	3	full exposure	1	2	3	H	0.002	0.1	H
13.8	11	Improper post-operational pain management	Any surgery (e.g. caesarean, displaced abomasum)	pain, behaviour disturbance	4	7	100	100	100	H	10	full exposure	20	30	40	H	2.1	7	H
13.7	12	Improper management of "Downer cow"	Lack of physiotherapy, good bedding, proper facilities and lifting devices	pain, behaviour disturbance, fear, frustration	4	15	90	95	100	M	15	full exposure	5	15	25	H	2.1375	15	H
6.11	13	Use of electric goods	--	pain, fear, injuries, altered behaviour	3	20	80	90	100	M	0.5	full exposure	5	10	15	H	1.35	15	H
13.1	14	Withholding necessary veterinary therapeutic health care / poor health care and welfare plan	e.g. claw trimmer	locomotion problems, pain	3	80	40	60	80	M	40	full exposure	20	30	40	H	10.8	60	H
12.3	15	Inadequate biosecurity	inadequate control of irritant insects	behaviour disruption	2	25	25	50	75	H	100	full exposure	30	50	70	H	3.125	12.5	H

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

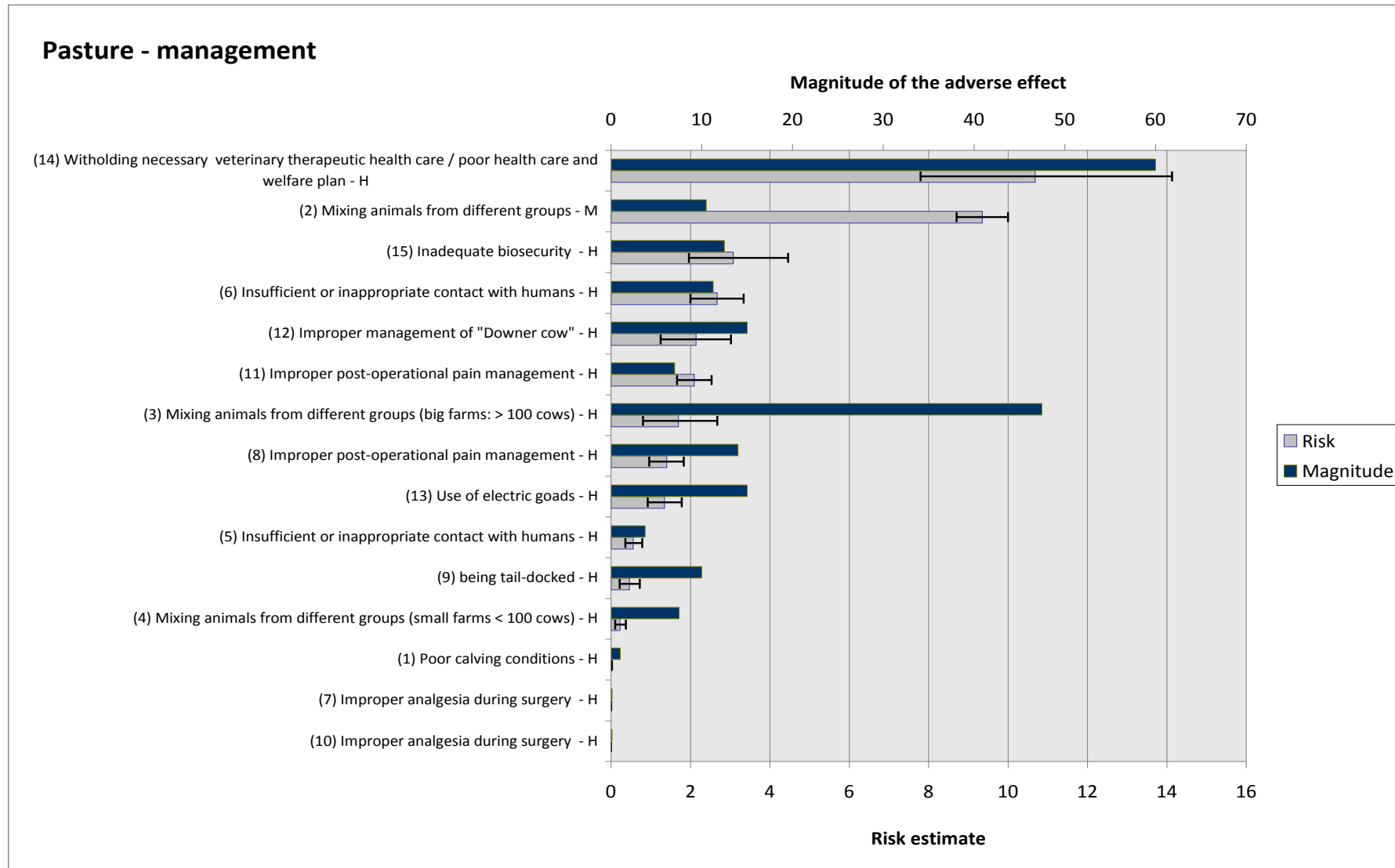


Figure 20. Ranking of hazards related to management in dairy cows kept in pasture.

PASTURE																			
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	increased constraint on time available for activities	1	120	30	40	50	H	325	estimated breeding value for yield in top quartile for breed and country	20	30	40	H	3.6	30	H
4.2	2	high genetic potential for production due to selection ignoring other traits	without good housing, nutrition and management	increased constraint on time available for activities	2	180	60	70	80	H	325	estimated breeding value for yield in top quartile for breed and country	40	50	60	H	31.5	90	H
4.2	3	high genetic potential for production due to selection ignoring other traits	With twice a day milking	Discomfort as a result of full udder	2	60	70	80	90	H	325	estimated breeding value for yield in top quartile for breed and country	20	30	40	H	7.2	30	H

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

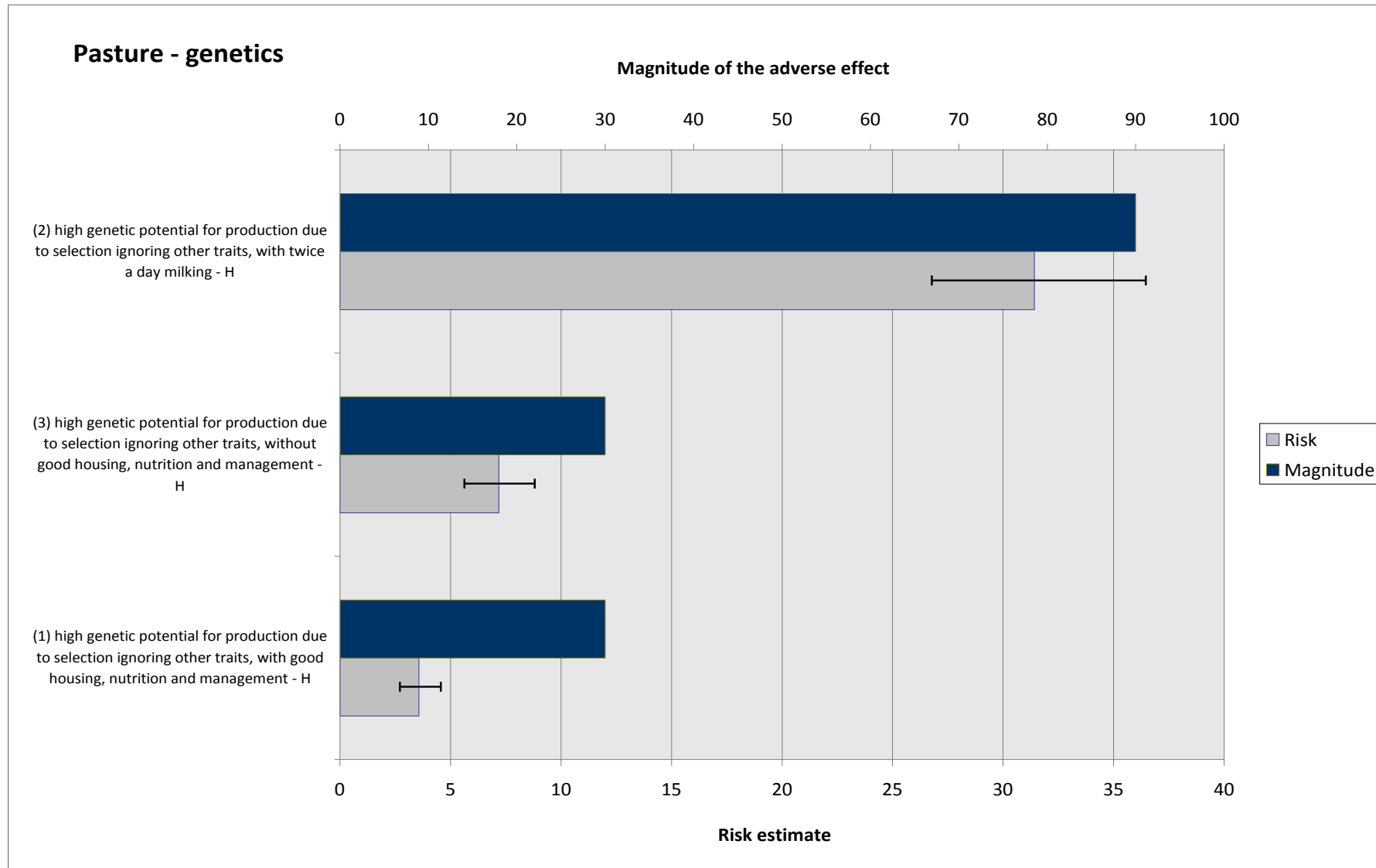


Figure 32. Ranking of hazards related to genetics in dairy cows kept in pasture.

GLOSSARY: RISK ANALYSIS TERMINOLOGY

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.