Wageningen UR Livestock Research

Partner in livestock innovations

Report 430

Fit for travel / Fitness during transport

Selectie van criteria om geschiktheid voor (lang) transport van varkens en rundvee te bepalen

December 2010

LIVESTOCK RESEARCH
WAGENINGEN UR

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Abstract
This report contains suggestions for parameters to be used as indicators of fitness to travel prior to the journey.

Keywords
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Samenvatting
In dit rapport worden parameters benoemd welke geschikt zijn om te gebruiken bij een beoordeling voorafgaand aan het transport en parameters die kunnen worden gebruikt om het effect van het transport en de beoordeling voorafgaande aan het transport te kunnen evalueren.

Trefwoorden
Transport, fitnes, indicatoren, monitoren

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Preface

According to the (Dutch) decree on transport an animal must be fit to travel. This is a requirement for all types of travel over long or short distances and is at present only marginally applied under Dutch law and in common practice with no distinction between long or short journeys. This mainly is due to the fact that there are insufficient technical and scientific data available. The Dutch government requires such information to determine whether or not an animal (or category of animal) is fit for travel in compliance with the transport decree.
This requirement has gained in importance because of an apparent tendency to transport animals over langer distances (which is contrary to the policy behind the animal welfare bill). An animal or category of animal may be fit or not to travel without risk to its welfare depending on the duration of the journey. However, in order to be able to set a limit to fitness for travel for different categories of animals certain criteria have to be identified and established.
This has led to two basic questions
1) Which criteria or parameters are available to determine fitness for travel for the various animal categories (i.e. culled dairy cows, calves, culled sows and piglets) prior to and during transportation for differing durations?
2) On which grounds can certain criteria or parameters be used to determine wether or not an animal or animal category is fit to travel for a certain duration?
Because the duration of the journey determines limitations within which it is justified to transport animals it is important, where possible, to answer both questions in relation to the different journey times in current practice (i.e. < 4 hours, 4 – 8 h, 8 – 12 h, 12 - 20 h, >20 h).
The Dutch ministry for agriculture has declared an intention to limit transportation of live animals over long distances. The present decree on transportation does not include any limitations to journey times as long as the compulsory resting periods are adhered to. As a result fattening pigs are transported to Russia and cattle intended for slaughter are to be transported to the Lebanon. This is an undiserable development. However, there is insufficient scientific evidence, in support of the ministry, for a fundamental debate on live animal transportation for durations above 20 hours based on animal welfare aspects (i.e. suitability of animals to travel such distances).
Livestock Research Wageningen UR has been requested to perform this study by Paul Bours (formerly LNV) of ELI.

Samenvatting

In dit rapport worden parameters benoemd welke geschikt zijn om te gebruiken bij een beoordeling voorafgaand aan het transport en parameters die kunnen worden gebruikt om het effect van het transport en de beoordeling voorafgaande aan het transport te kunnen evalueren. Door het meten van specifieke parameters kunnen criteria benoemd worden welke gebruikt kunnen worden in een monitoring protocol om uniformiteit in de beoordeling te creëren voor het al dan niet toelaten van lang (>8 uur) of kort (<8 uur) transport.

Waarnemingen aan (landbouwhuis)dieren rond transport gebeurt op dit moment binnen de EU niet op een gestandaardiseerde manier. Hierdoor zijn gegevens slecht vergelijkbaar en worden er ook onvoldoende gegevens verzameld. Op dit moment is het niet mogelijk aan te geven binnen welke marges mogelijke parameters moeten vallen om te bepalen of dieren fit genoeg zijn om getransporteerd te worden of om ervoor te zorgen dat welzijn of gezondheid niet in het gedrang komt gedurende het transport. Als onderdeel van de ontwikkeling van een monitoringsprotocol, moeten derhalve de marges waarbinnen de parameters (voorafgaand aan of tijdens het transport) horen te vallen om te oordelen over de geschiktheid voor transport, nader worden bepaald. Dit rapport richt zich niet op de eisen aan de methode, middelen of omstandigheden waaraan het transport (wettelijk) zal moeten voldoen, maar richt zich op het bepalen van de fysieke en fysiologische condities van de dieren voorafgaand, tijdens en na het transport. Aan de hand van fysieke en fysiologische parameters moet kunnen worden bepaald of een dier geschikt is voor transport.

Een uitgebreide literatuurstudie naar parameters welke gerelateerd zijn aan de fysieke en fysiologische status van dieren, heeft geresulteerd in lijsten per diersoort met potentiële parameters, welke in de bijlage zijn opgenomen. Vervolgens zijn de parameters geselecteerd en ingedeeld aan de hand van de meest belangrijke risico's zoals benoemd in de workshop 'Hazard identification during transport' (van Reenen et al, 2008) welke de dieren lopen tijdens en na het transport. Hieruit volgt een selectie van meest belangrijke en geschikte parameters welke ingezet kunnen worden in een gestandaardiseerd monitoringsprotocol. Om de marges te kunnen bepalen waarbinnen de parameters moeten vallen om te bepalen of de dieren geschikt zijn voor het transport, is een evaluatie protocol nodig na afloop van het transport. In eerste instantie worden de normaal waardes aangehouden welke vanuit klinische diagnostiek worden voorgeschreven. Deze normaalwaardes zeggen iets over de fysieke toestand van een dier op een bepaald moment, maar niet hoe het dier zal reageren op een belasting door transport.

Om tot een geschikt monitoringsprotocol te komen, is een raamwerk opgezet dat geëvalueerd kan worden in de praktijk. Het raamwerk bestaat uit 4 stappen voor kort transport (tot 8 uur) en uit 5 stappen voor lang transport (> 8 uur) en zal als leertraject moeten dienen om tot een methode te komen die eenduidig is en goed uitvoerbaar door (internationaal) controlerende instanties.

Raamwerk voor de ontwikkeling van een monitoringsprotocol

1. Stal keuring maximaal X aantal dagen voorafgaand aan het transport bestaande uit:
    a. Klinische inspectie van de te transporteren dieren op het bedrijf.
    b. Lab onderzoek bij individuele dieren. Koppels gezonde dieren: 1 dier per X aantal dieren. Individuele dieren, koppels < X aantal dieren: alle dieren bemonsteren
2. Klep keuring: klinische beoordeling op het moment van laden: voor kort of lang transport of tijdens lang transport
3. Compartimentenkeuring tijdens lang transport
4. Rustkeuring tijdens lang transport
5. Los keuring: klinische beoordeling op moment van lossen (tijdens lang transport of aan eind kort transport.
6. Evaluatie onderzoek bestaande uit:
    a. Slacht bevindingen
    b. Lab onderzoek van dezelfde dieren welke bemonsterd zijn voorafgaand aan transport
    c. Sterfte % en sectie van gestorven dieren tijdens transport
    d. Ziekte, sterfte en uitval gegevens tot 1 maand na transport (sterfte, ziekte, abortus, afvoer)

Summary

This report contains suggestions for parameters to be used as indicators of fitness to travel prior to the journey. Measurement of certain parameters provides recognition of criteria which form the basis of a monitoring protocol to improve uniformity of judgement of suitability for short (< 8 h) or long (> 8h) distance journeys.
At present in the EU, observation of (agricultural) livestock intended for transport is not standardized. Consequently, comparison of data is difficult and insufficient. It is difficult to determine within which margins parameters must fall to enable estimation of fitness to travel or to establish whether or not animal health and welfare will be compromised during the journey. As part of the development of a monitoring protocol, attention has to be paid to the margins within which the parameters (prior to or during transport) have to comply to allow determination of suitability for transport. This report does not address the legal requirements of the method, means or conditions, but considers the determination of physiological and physical conditions of the animal prior to, during and after transportation. It must be possible to determine fitness to travel using physical and physiological parameters prior to transportation.
A detailed study of literature to identify parameters related to the physical and physiological state of the animal resulted in the list per animal category of potential candidate parameters presented in the appendix. Thereafter, the parameters were selected and allocated according to the potential risks to animals during and after transport as identified during a recent workshop “Hazard identification during transport” (van Reenen et al, 2008). Subsequently, a selection was made of the most important and appropriate parameters for use in a standardized monitoring protocol. An evaluation protocol is required after each journey, in order to determine the ranges within which these parameters must fall to allow determination of fitness to travel. Initially, the normal values based on clinical diagnosis were retained. These values give an indication of the physical state of an animal at a particular moment in time, but do not indicate how the animal will react to the extra burden from transportation.
A framework has been established for a practical evaluation of an appropriate monitoring protocol. This framework consists of 4 steps for short journeys (up to and including 8 h) and 5 steps for longer journeys (> 8 h) that should function as a learning process towards a clear and practicable method for use by (international) controlling bodies.

Framework for the development of a monitoring protocol.

1. On farm inspection maximally X days prior to transport consisting of:
    a. Clinical inspection of the animals to be transported from the farm.
    b. Laboratory analyses of individual animals. Groups of healthy animals: 1 of every X animals. Individual animals, groups < X animals: all animals sampled.
2. Inspection during loading: clinical inspection during loading before short or long journeys or during long journeys
3. Compartment inspection during long journeys
4. Inspection during resting periods on long journeys
5. Inspection upon arrival: clinical inspection at moment of unloading (during long journeys or at the end of short journeys).
6. Evaluation consisting of :
    a. Slaughter results
    b. Laboratory analyses of same animals analysed prior to transit.
    c. Mortality % and autopsies of animals that died during transit
    d. Registration of data concerning disease, deaths and irregularities (i.e. abortions, culling) up to 1 month after transport

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1 Introduction

1.1 Background

Transportation of production animals is a daily occurrence[1]. Almost all agricultural livestock will experience long or short transportation within their lifetime. Transport distances are on the increase due to the fact that there are fewer slaughterhouses and trade (exchange) in live animals is also on the increase. This transport forms a possible risk to animal health and welfare. Potential risks during transport occur during loading and unloading, with exposure to new surroundings (during and after transit), mixing with unknown animals, lack of food and water, vibration during transport and the spread of germs from contact with companion animals.
An objective method is required to determine the suitability of animals to travel long (>8 h) or short (<8 h) distances. Development of such an objective determination method will provide clear guidelines and uniformity of judgement concerning the acceptability of animals for various transport durations.

Animals destined for transport can be categorized as follows:

- Groups v Individuals
- Healthy v Diseased or problem livestock
- Young v Old
- Removal for slaughter v Transfer to alternative farm

In the dairy industry this concerns mainly individual animals (or small groups) i.e. cull cows, dry cows for beef, pregnant heifers or young calves for transfer to another farm.
Beef cattle are often transported in groups, although these animals are often mixed as the animals are become ripe for slaughter.
A group comprising individual culled animals from various origins requires individual inspection of each animal as a group approach would increase the risk of not detecting individual problem cases.
Risks during transport are greater for younger animals than for older ones due to lower reserves and increased demand on the environment during growth.
Fitness of the animal can be assessed in several ways. These can vary from a limited to an intensive clinical examination involving blood analyses and heart beat monitoring. In general, measurements or examinations that do not involve touching the animals are to be preferred in order to eliminate the risk of influencing the measurement. Especially with animals that are not acquainted to being handled (extensively reared young stock), contact can lead to such an increase in stress that the results will be confused as to the source of the stress. On the other hand, use of invasive measuring methods (e.g. use of injection needles) can burden the animals more than those methods that do not compromise the integrity of the animal (e.g. heart beat registration using adhesive electrodes).
The schemes presented in the appendices contain an overview of potential measurement methods for determination of “fitness to travel” and “fitness during travel”. Several of the methods mentioned have been scored in order to indicate suitability. A ‘+’ indicates an advantage of the method (e.g. acceptable or cost efficient), A ‘-‘indicates reduced acceptance of the parameter. After summation of the positive and negative points an indication can be given for an unbiased appraisal of the applicability of the method in question.
Each animal category mentioned has its specific characteristic (healthy v possibly diseased) risks (young v old). For each group there is a separate scheme indicating the possibilities and relevance. In addition, an overview is given of the potential risks during transport and how these can be assessed through the animal. Frequency of determination of “fitness” will depend on the duration of the journey and the state of the animal prior to transit.

[1] According to the commodities board for livestock, meat and eggs (PVE) more than 6 million piglets and 4.8 million fattening pigs and sows were exported in 2008. In 2008 more than 1 million pigs were imported. Approximately 45% of the sows were removed (ca. 540.000 sows culled).
In 2008, almost 190.000 lambs and 35.000 goats were sent abroad while 40.000 sheep and goats were imported. According to Veepro approximately 21000 pregnant heifers were exported. PVE reports that 580.000 cattle were exported in 2008. Each year approximately 25% of the dairy cow herd are replaced (372.000 cull cows) and roughly 75% of the newly born calves are traded (ca. 1.1 million, of which 122.000 for export).
Approximately 5000 horses were exported and more than 28000 imported in 2008.

2 Parameters

2.1 Fitness parameters

Appendices 1a – 1e contain parameters for cattle and for various categories of pigs that can be used to judge whether or not animals are fit to travel. For cattle categories (intact calves, breeding calves, breeding heifers, cull cattle, beef calves, rose veal calves, beef bulls, beef cattle) no further distinction has been made, while for pigs (weaned piglets, fattening pigs, breeding gilts and cull sows) this has been made.
The classifications in the appendices are similar: clinical examination, blood values, urine, faeces and others.

- Clinical examination is divided into respiration, heart beat, temperature, skin, behaviour, distinguishing irregularities, weight/condition, mucous membranes and lymph nodes. These are the important parameters for examination during and after transit.
- Blood values are divided into virological analysis parameters i.e. red and white blood components, pH levels, oxygen content, electrolyte content, protein levels, enzyme levels, energy levels, presence of stress hormones, fatty liver syndrome, trace elements, cholesterol, creatine and fatigue.
- Meat,
- Urine,
- Faeces
- Other parameters.

Where possible the normal values/ profiles have been indicated along with the relevance of the parameter, an indication of the potential of the parameter, whether or not further research is required and the costs involved, practicability and whether or not the parameter requires invasion of the animals integrity. Additionally, an indication is given as to whether or not the parameter is a good indicator of fitness to travel (the -/+ is not always indicated since the value for fitness to travel is not always evident).
Present EU law[2] states that sick animals may not be transported. Here, on the basis of observation of the animals (locomotion, wounding, weakness), it is determined whether or not animals experience (extra) pain during transportation in relation to their physical condition i.e. birth/parturition and length of gestation (<90%). Other regions employ similar rules and regulations. Australia does not allow transportation of animals blind in both eyes[3]. Parameter measurement (clinical examination as well as laboratory analyses) should be repeatable (eventually after some training), specific to aim, present no extra burden to the animal, be performed with a minimum of effort and allow administration and results should be immediately available (at loading).

2.2 Parameters related to risks during transportation

An overview is given in appendices 2a – 2b of the parameters that according to literature relate to transport/risks during transport. A distinction is made between parameters that (especially) concern animal reactions to fasting, lack of water, disruption of normal behaviour, temperature/ventilation, injury and other stress factors (new companion animals, disturbance of the ranking order, full udder, new environment, loading/unloading, vibration of the vehicle, limited space). Additional parameters have been listed that display a relationship with animals that drop out. Although the overview is (presently) incomplete it is obvious which parameters should be considered. It is also obvious that changes in measured values themselves are not clear and remain strongly dependent upon conditions during transit and at loading and unloading, differences between animal categories, possibly due to breed (temperament) and season (weather). Normal values or profiles observed in international literature do not provide good comparisons due to differences in determination methods.
Transport is divided into long (longer than 8 h) and short transport up to a maximum of 8 hours. According to EU-regulations[4] during long journeys there should be a resting period which differs for each type or category of animal. Vehicles used for journeys longer than 8 h must comply with special requirements.

[2] Appendix 1 of EU nr 1/2005 for the protection of animals during transportation and other related activities: suitability for transportation.
[3] Pre-transport selection of livestock. Australian standards and guidelines for the welfare of animals- land transport of livestock, edition 1.
[4] EU bill 1/2005 on the protection of animals during transportation and related activities. Chapters V and VI.

3 Risks during transportation

A recently held workshop “Hazard identification during transport” resulted in a report (van Reenen et al. 2008) in which was stated that the greatest proportion of the estimated risks during transport is similar for most animals. These risks include: poor ventilation, lack of space, duration of journey, lack of (suitable) food and water, incorrect handling of animals during loading and unloading, unfit animals prior to transit, exposure to pathogens before and during transit and failure to allocate and allow correct resting periods during long journeys. Different groups have different risks. Transportation of young animals especially, entails specific risks.

Parameters have been identified and selected as potential indicators relevant to the risks involved. Where possible the risks are divided into the following critical areas:
Food shortage
Water shortage
Thermoregulation
Injuries
Disturbance of normal behaviour
Stress resulting from mixing of animals, loading/unloading, vibration of vehicle, restricted ventilation, restricted space
Exposure to micro-organisms (pathogens)

4 Most appropriate criteria for reference values

4.1 Fit to travel

4.1.1 On-farm inspection

Most cattle are taken from the farm as individuals or in small groups. This is the case with intact calves (often collected once a week), pregnant heifers (individually or several heifers of similar age removed together) and cull cows. Depending on the reason for removal, these animals are removed individually or in small groups of 5 or less. It is often not practicable to perform individual on-farm inspections before such removals/transportations occur. In such cases judgement of fitness to travel is deffered to inspection at loading.
As cattle farms increase in size, the tendency will be to move more animals in groups. The status of a group of intact calves on-farm is different to that of a group of bulls: intact calves are reared as individuals on-farm and therefore do not form a group. Other categories (i.e. breeding heifers, old cows) are often selected from a larger on-farm group.
A proportion of the cattle and pigs are taken from a farm (or auction) to an assembly point (for export) from which they are transported further. A clinical inspection may be performed at the assembly point. Because these animals remain at the assembly point for a limited period, results from laboratory analysis may appear disturbed (affect of transport). Moreover, speed of analysis determines whether or not results are made available before continuation of transport.
Beef cattle (bulls, beef- and rose veal calves and grazing cows) are often shipped in groups and may in practice receive an on-farm inspection. This is also the case for all categories of pig except cull sows.
Generally, there is a more rigid transportation plan for groups than for transport of individuals or small groups of animals.
For this reason the inspection of groups is easier to accommodate and less taxing for daily management than daily inspection of individuals or small groups. In Table 1a and 1b an asterisk (*) indicates which type of inspection is considered reasonable to perform.

Table 1a. Most common forms of transportation for cattle (between units)[5]

Category	From – destination	Individual/group		Inspection		
				Farm	Loading	unloading
Intact calves (>10 days)	Farm- farm	Individual			*	*
	Farm – assembly point	Individual			*	*
	Assembly point - farm	Group	Import/export	*	*	*
Breeding calves	Farm – Breeding farm	Individual/small group			?	
Breeding heifers	Breeding farm - farm	Individual/small group			?	
	Farm – farm	Individual/small group			*	
	Farm – assembly point	Individual/group			*	*
	Assembly point - farm	Group	Import/export	*	*	*
Cull cattle[6]	Farm - farm	Individual/small group			*	
	Farm – slaughterhouse	Individual/small group			*	*
	Farm – assembly point	Individual/small group			*	*
	Assembly point - farm	Group	Import/export	*	*	*
	Assembly point – slaughterhouse	Group	Import/export	*	*	*
Beef calves	Farm – slaughterhouse	Group		*	*	*
Rose veal calves	Farm - slaughterhouse	Group		*	*	*
Beef bulls	Farm - slaughterhouse	Group		*	*	*
	Farm – assembly point	Group		*	*	*
Beef cattle (weaned calves, grazing calves)	Farm - slaughterhouse	Individual/group			*	*
	Farm – assembly point	Group		*	*	*
	Assembly point - slaughterhouse	Group		*	*	*

Tabel 1b. Most common forms of transportation for pigs (between units)

Category	From – destination	Individual/group		Inspection		
				Farm	loading	unloading
Weaned piglets	Farm – farm	Group		*	*	*
	Farm – assembly point	Group		*	*	*
	Assembly point - farm	Group	Import/export	*	*	*
Breeding gilts	Farm – farm	Group		*	*	*
	Farm – assembly point	Group		*	*	*
	Assembly point - farm	Group		*	*	*
Fattening pigs	Farm - slaughterhouse	Group		*	*	*
	Farm – assembly point	Group		*	*	*
	Assembly point – slaughterhouse	Group	export	*	*	*
Cull sows	Farm - slaughterhouse	Individual/small group			*	*
	Farm – assembly point	Individual/small group			*	*
	Assembly point - slaughterhouse	Group		*	*	*

[5]Transportation of animals within farms/businesses over distances of less than 50 km are subject to the general terms for transportation of animals.

[6] An auction or market can also be regarded as an assembly point for cattle. Here it concerns mostly cull cattle accepted/removed and relatively few animals for the beef cattle husbandry sector.

4.1.1.1 Clinical inspection

Several parameters have been selected from the list of criteria in the appendices:

- Practicability,
- Should cost the stockholder and inspector as little time as possible,
- No safety risk to inspector,
- Should not be a (extra) burden to the animal
- Should be sufficiently discriminatory.

Tables 2a and 2b contain overviews of the parameters and reference values for cattle and pigs.

Table 2a. On-farm clinical inspection: parameters and reference values for cattle

Parameter	**Method**	**Ref. value**	**Comments**
Body score	ASG	>1.25	Not extremely thin
Wounds/swelling	ASG	< 6 cm	
Fractures		None	
Dung consistency	Welfare Quality	>1	
Locomotion	Manson&Leaver	<4	
Deep seated eyes	Welfare Quality	Not	
Colour mucous membranes	Welfare Quality	Rose	
Shallow breathing	Welfare Quality	None	
Alertness	Welfare Quality	Alert/active	
Discharge eyes, nose, vulva	Welfare Quality	None	
Length gestation		<8.5 months	
Recently calved		> 3 days	
Recently castrated/ dehorned		wound healed	
Obviously ill	If thought sick then examine further:		
- body temperature	Measure	38.6 ±0.5	
- heart beat	Count	48-84	
- respiration frequency	Count	26-50	

Tabel 2b. On-farm clinical inspection: parameters and reference values for pigs[7]

Parameter	Category				Method	Ref. value	Comments
	piglet	gilt	fattener	sow			
Body score	*	*	*	*			
Wounds	*	*	*	*			
Swollen joints	*	*	*	*			
Fractures	*	*	*	*		None	
Locomotion	*	*	*	*		Walk freely on all four feet	
Deep seated eyes	*	*	*	*		Not	
Hair condition	*					Flat	
Skin colour	*						
Head posture	*					Central/balanced	
Colour mucous membranes	*	*	*	*		Rose	
Deep breathing (from abdomen)	*	*	*	*		None	
Alertness	*	*	*	*		Alert/active	
Discharge eyes, nose, vulva	*	*	*	*		None	
Length gestation				*		< 15 weeks	
Recently farrowed				*		> 3 days	
Recemtly castrated	*					Wound healed	
Obviously ill					If thought sick then examine further:		
- body temperature	*	*	*	*	Measure	38 – 39.5	
- heart beat	*	*	*	*	Count	70 -120	
- respiration frequency	*	*	*	*	Count	8 – 18	

[7] There are different parameters and reference values in appendices 1b t/m 1e for different categories of pigs.

4.1.1.2 Laboratory examination

The results obtained from the laboratory examination taken during the on-farm inspection in relation to the suitability or fitness of an animal for transportation, should be repeatable and specific to the condition of the animal at the moment of examination (or allow an estimation of the condition). Unstable, rapidly changing parameters are here not appropriate. The results and assessment should be available within a few days prior to embarkation to allow for any alterations to the planned journey. This on the condition that the conditions where the animals are housed (rested) remain constant. If conditions vary then the analysis results have little baring on their prediction value and then the period between sampling and transportation should be shortened.

Blood is the most acceptable medium since it is present in all categories (as opposed to milk), sampling procedure can be standardized and easy to perform (as opposed to urine) and provide little or no extra burden to the animal. Additionally, the taking of a blood sample can in itself provide a source of stress to the animal, especially when animals are not accustomed to "handling" this may influence the results. Restraining animals prior to sampling can often cause more stress than the actual taking of a blood sample. For this reason only blood samples are advised for the on-farm inspection.

Criteria fit to travel:
The problem is to determine which parameters or combinations of parameters under which circumstances indicate that an animal is unfit to travel. When does the welfare of the animal become compromised during transportation? Is there a single parameter with the power to distinguish and within which range of values? It remains uncertain whether or not the criteria for short (< 8 h) or long (> 8 h) journeys will be similar. In order to assess this evaluation of the animals will have to be performed after transit.

Table 3a. On-farm laboratory inspection of cattle (different reference values may apply to different categories)

Parameter	Method	Ref. values	Comments
Hb	Standard	5-8 mmol/l Fe	
Hematocriet	Standard	.27 - .36 l/l	
Leucocytes	Standard	5 – 10 10^9/l	
BHBA	Standard	< .9 mmol/l	
Nefa's	Standard	< .59 mmol/l	
Glucose	Standard	2.9 – 4.4 mmol/l	
TP	Standard	60 – 90 g/l	
Creatine kinase	Standard	< 125 U/l	
Base excess	Blood gas analysis	-1.58 ±3·04	Barzani
Saturation	Blood gas analysis		
Acidification	Blood gas analysis		

Table 3b. On-farm laboratory inspection of pigs (different reference values may apply to different categories)

Parameter	Method	Relevance				Comments
		piglet	gilt	fattener	sow	
Hb	Standard	*	*	*	*	6.2 – 8.7 mmol/l Fe
Hematocriet	Standard	*	*	*	*	35 – 45 l/l
Leucocytes	Standard	*	*	*	*	10 – 18 10^9/l
Glucose	Standard	*	*	*	*	3.3 – 4.0 mmol/l
Lactate		*	*	*	*	30-50 mg/100ml
pH		*	*	*	*	7.35-7.45
Base excess	Blood gas analysis	*	*	*	*	-6. 0 – 1.5
Saturation	Blood gas analysis	*	*	*	*	
Acidification	Blood gas analysis	*	*	*	*	
Urine pH		*	*	*	*	7-4 – 8.4
Urine sg		*	*	*	*	1.01 – 1.03

4.1.1.3 Sample size.

Animals that, on the hand of the clinical analyses, are doubtful yet are allowed to travel should always be sampled. Moreover, groups of (sick animals are never transported[8]) 6 or more healthy animals and one in every 20 animals should be sampled (often median animal based on animal ear number). Groups of less than 6 and individual animals are not sampled. It is the intention to obtain information on as many different groups (conditions prior to transport) as possible to compare data from the clinical analyses (using laboratory data for evaluation).

Table 4. Sample size for different group sizes

Group size	Sample size	Comments
5 or less	0	No on-farm inspection
6 – 20	1	Discussion: as many groups as
21 – 40	2	possible with differing circumstances
41 – 60	3	
61 – 80	4	

4.1.2 Inspection during loading

During loading of cattle a clinical inspection is possible to determine whether or not an animal is fit to travel. Within present legislature a screening is performed of animals intended for transportation (by those who offer the animal for transportation and those who transport the animal) to determine fitness for travel (chapter 1, appendix 1 transport bill EG 1/2005). In practice a more detailed examination should be made at loading by those responsible for transporting the animals and the driver of the vehicle. Only when transporting groups of animals should the responsibility be with others. The amount of administrative procedures then greatly increases (prior to planned departure time).

For these inspections the following parameters apply:
- Repeatability of scoring (eventually after some training),
- Distinguishing power,
- practicable method,
- no (extra) burden to the animal,
- safety of inspector.

[8] According to EU bill 1/2005 chapter I, fitness to travel should involve:
1. Only those animals considered suitable for the intended journey, and transport conditions should be such that they do not threaten the safety and health of the animal.
2. Injured, weak and sick animals are not considered suitable for transportation, under the following circumstances:
   a) whenever an animal is not able to move or walk unassisted and without pain;
   b) whenever they have a serious open wound or prolapse;
3. Sick or injured animals can be considered for transport under the following conditions:
   a) when there is no extra burden to lightly injured or sick animals; by doubt seek veterinary advice;
   b) whenever they are to be transported under directive 86/609/EEG of the EU council (1) when sickness or injury occurs as part of a research programme;
   c) when they are transported under veterinary supervision for or following veterinary treatment or inspection. This transport may only be allowed when it does not entail unnecessary suffering to the animal or ill treatment.
   d) whenever animals have been subjected to veterinary procedures related to agricultural practice, i.e. dehorning or castration, only if the wounds have completely healed.

Table 4a. Clinical inspection during loading: parameters and reference values for cattle

Parameter	Method	Ref. values	Comments
Body score	ASG	>1.5	
Wounding/swelling	ASG	< 6 cm	
Fractures		None	
Locomotion	Manson&Leaver	<4	
Deep seated eyes	Welfare Quality	No	
Colour mucous membranes	Welfare Quality	Rose	
Shallow breathing	Welfare Quality	No	
Alertness	Welfare Quality	Alert/active	
Discharge eyes, nose, vulva	Welfare Quality	None	
Gestation length		<8.5 months	
Recently calved		> 3 days	
Recently castrated/ dehorned		Wounds healed	
Obviously ill	If thought sick then examine further:		
- Body temperature	Measure	38.6 ±0.5 (< 39.5)	
- heart beat	Count	48-84 (< 90)	
- respiration frequency	Count	26-50 (< 50)	

Table 4b. Clinical inspection during loading: parameters and reference values for pigs[9]

Parameter	Category				Method	Ref. values	Comments
	Piglet	Gilt	fattener	sow			
Body score	*	*	*	*			
Wounds	*	*	*	*			
Swollen joints	*	*	*	*			
Fractures	*	*	*	*		None	
Locomotion	*	*	*	*		Walk freely on all four feet	
Deep seated eyes	*	*	*	*		None	
Head posture	*					Central/balanced	
Hair/coat	*					Flat	
Colour mucous membranes	*	*	*	*		Rose	
Deep/abdominal breathing	*	*	*	*		None	
Alertness	*	*	*	*		Alert/active	
Discharge eyes, nose, vulva	*	*	*	*		None	
Gestation length				*		< 15 weeks	
Recently farrowed				*		> 3 days	
Recently castrated	*					Wound healed	
Obviously ill	If thought sick then examine further:						
- Body temperature	*	*	*	*	Measure	increased (> 39.5)	
- heart beat	*	*	*	*	Count	increased (> 70)	
- respiration frequency	*	*	*	*	Count	Increased (> 18)	

4.1.3 Inspection upon arrival

Inspection upon arrival is performed to indicate whether or not the welfare of the animals, based on the criteria assessment prior to transportation, has been maintained. Routine inspection during unloading, by others than the driver of the vehicle, is only possible while unloading groups of animals at the place of slaughter or at an assembly point. In order to obtain a reliable indication all animals that have been transported have to be removed from the vehicle and monitored. The arrival inspection can be used as an assessment for fitness to travel further, should the transit be continued.

[9] Different parameters and reference values for diverse categories of pigs are given in appendices 1b through to 1e.

Table 5a. Measurements that can be performed on the animal during unloading of cattle[1]

Parameter	Method	Ref. values	Comments
Injuries (skin, horns, vulva)	ASG	< 6 cm	
Fractures		None	
Locomotion	Manson&Leaver	<4	
Rumen fill	Welfare Quality		
Shivering	Welfare Quality	No	
Panting	Welfare Quality	No	
Sweating	Welfare Quality		
Slipping/falling	Count	No	
Shallow breathing	Welfare Quality	None	
Alertness	Welfare Quality	Alert/active	
Death	Count		
Obviously ill	If thought sick then examine further:		
- body temperature	Measure	38.6 ±0.5	
- heart beat	Count	48-84	
- respiration frequency	Count	26-50	

[1] Monitoring of unloaded animals is only envisaged for evaluation purposes.

Table 5b. Measurements that can be performed on the animal during unloading of pigs

Parameter	Method	Ref. values	Comments
Skin damage		< 6 cm	
Hair/coat		Flat	Piglet
Fractures		None	
Locomotion		Walk freely on all four feet	
Shivering		No	
Panting		No	
Slipping/falling	Count	No	
Shallow breathing		None	
Alertness		Alert/active	
Death	Count		
Obviously ill	If thought sick then examine further:		
- body temperature	Measure	38 – 39.5	
- heart beat	Count	70 -120	
- respiration frequency	Count	8 – 18	

During this inspection particular attention is paid to any changes (arising from) that have taken place during transit: values observed during the clinical inspection are compared to the reference values. Several values for parameters are presented in the appendices. Tables 5a and 5b contain the most important parameters. Here a distinction is made in parameters for short and long distance journeys (laboratory evaluation analyses account for differences in parameters).

4.2 Fit during transport

According to EU-legislation[10] resting periods based on animal category have to be observed during long journeys. If vehicles do not comply with special requirements the transit time of cattle and pigs may not exceed 8 hours.
If vehicles do comply with special requirements (i.e. compartments, flooring, bedding, minimum age or body weight requirements, water and feed supply), then transportation may continue for longer periods under the following conditions:

- Calves and unweaned piglets must have a compulsory 1 hour rest after 9 hours transportation. During this rest they should have access to clean drinking water and be fed if necessary. Thereafter, they may be transported for a further 9 hours.

[10] EU bill 1/2005 on the protection of animals during transportation and related activities. Chapters V and VI.

- Older cattle and pigs must be rested after a maximum of 14 hours transport for 1 hour during which they should have access to clean drinking water and be fed if necessary. Thereafter, they may transported for a further 14 hours.
- There are separate demands for air and sea transport.

During long journeys inspection can be performed in the compartment while travelling or during resting periods or at unloading and loading at resting points. This to determine whether or not the animals are well enough (fitness during travel) to continue their journey. This is based on the same parameters and criteria as for fitness to travel. The possibilities for clinical inspection of animals in the compartment are restricted by limited space, with less room to inspect the appearance of the animals.

4.2.1 In compartments

Clinical (visual) appraisal of animals during transit is very difficult, especially for animals transported on several decks. Severe damages can be observed on video without having to enter the compartment and mix with the animals. There is also the possibility of placing monitoring devices in or on the body of the animal for registration i.e. heart beat and body temperature. In practice the use of such devices constitutes a disturbance of the daily routine of the animals and an extra burden for the transporters. Measurement on the animal as presented in tables 6a and 6b requires use of camera's and registration equipment.

Table 6a. Measurements that can be performed on the animal during transportation of cattle

Parameter	Method	Ref. values	Comments
Injuries (skin, horns, vulva)	ASG	< 6 cm	
Fractures		None	
Shivering/panting/sweating	Welfare Quality	No	
Slipping/falling	Count	No	
Alertness	Welfare Quality	Alert/active	
Death			
- body temperature	Measure	38.6 ±0.5	Equipment
- heart beat	Count	48-84	Equipment

Table 6b. Measurements that can be performed on the animal during transportation of pigs

Parameter	Method	Ref. values	Comments
Skin damage		< 6 cm	
Hair/coat		Flat	Piglet
Fractures		None	
Locomotion		Walk freely on all four feet	
shivering/panting/tongue hanging out		No	
Slipping/falling	Count	No	
Alertness		Alert/active	
Death	Count		
- body temperature	Measure	38 – 39.5	Equipment
- heart beat	Count	70 -120	Equipment

4.2.2 During resting periods

The objections to clinical inspection during transit are slightly less relevant for inspections held during resting periods when the animals remain in the vehicle. Observation of the animals from outside is often (limited) possible through ventilation openings or open flaps or doors. Due to the limited view only observation of severe damage is possible.

Table 7a. Measurements that can be performed on cattle during resting periods

Parameter	Method	Ref. values	Comments
Injuries (skin, horns, vulva)	ASG	< 6 cm	
Fractures		None	
Locomotion	Manson&Leaver	<4	
Rumen fill	Welfare Quality		
Shivering	Welfare Quality	No	
Panting	Welfare Quality	No	
Sweating	Welfare Quality		
Slipping/falling	Count	No	
Shallow breathing	Welfare Quality	None	
Alertness	Welfare Quality	Alert/active	
Death			
Obviously ill	If thought sick then examine further:		
- body temperature	Measure	38.6 ±0.5	Equipment
- heart beat	Count	48-84	Equipment

Table 7b. Measurements that can be performed on pigs during resting periods

Parameter	Method	Ref. values	Comments
Skin damage		< 6 cm	
Hair/coat		Flat	Piglet
Fractures		None	
Locomotion		Walk freely on all four feet	
Shivering		No	
Panting		No	
Slipping/falling	Count	No	
Shallow breathing		None	
Alertness		Alert/active	
Death	Count		
Obviously ill	If thought sick then examine further:		
- body temperature	Measure	38 – 39.5	Equipment
- heart beat	Count	70 -120	Equipment

4.2.3 During unloading/loading

At resting places when the animals are removed from and later loaded on to the vehicle, inspection can take place (Tables 8a and 8b) to determine whether or not animals are fit enough to continue their journey. Aspects such as gestation and calving/farrowing are not addressed since this has taken place at the beginning of the journey.

Table 8a. Measurements that can be performed on cattle during unloading/loading.

Parameter	Method	Ref. values	Comments
injuries (skin, horns, vulva)	ASG	< 6 cm	
Fractures		None	
Locomotion	Manson&Leaver	<4	
Rumen fill	Welfare Quality		
Shivering/panting/sweating	Welfare Quality	No	
Slipping/falling	Tellen	No	
Shallow breathing	Welfare Quality	None	
Alertness	Welfare Quality	Alert/active	
If thought sick then examine further:			
- body temperature	Measure	38.6 ±0.5	
- heart beat	Count	48-84	
- respiration frequency	Count	26-50	

Table 8b. Measurements that can be performed on pigs during unloading/loading.

Parameter	Method	Ref. values	Comments
Skin damage		< 6 cm	
Hair/coat		Flat	Piglet
Fractures		None	
Locomotion		Walk freely on all four feet	
Shivering/panting		No	
Slipping/falling	Tellen	No	
Shallow breathing		None	
Alertness		Alert/active	
If thought sick then examine further:			
- body temperature	Measure	38 – 39.5	
- heart beat	Count	70 -120	
- respiration frequency	Count	8 – 18	

4.3 Evaluation-research

An evaluation of the transportation is necessary to determine whether or not the parameter values for on-farm, unloading or arrival (i.e. continuation of transport) inspections can guarantee a high value for welfare status. In addition it must also be clear which levels of welfare are acceptable during transportation and which levels are considered too low and require adjustment. Reference values are not available for all parameters mentioned in literature. Therefore, an evaluation can provide a basis for the development of reference values for such parameters and improve insight into animal welfare before, during and after transport.

The evaluation can be divided into 4 parts:
- Investigation of slaughter parameters,
- Continued inspection of animals that have been laboratory tested,
- Autopsy of animals that died during transport
- Examination of clinical- and production data from animals upto a month after transportation.

Hereafter a short description of these parts. It is important that the specifications for transportation (method of transport, circumstances, group composition, duration of journey, treatment after transportation) are documented in a protocol for all parts of the evaluation.

4.3.1 Slaughter parameters

During a period of at least one year slaughter data could be compiled of animals that were transported to the slaughterhouse and which had been inspected on-farm, at loading and upon arrival (to allow for weather conditions, seasonal influences) of diverse categories of cattle (beef calves, rose veal calves, beef bulls, cull cows, grazing cattle). Literature suggests that not only the duration of transport but also the season, the ration fed prior to transport, breed and temperament of the animal contribute to the variation. Additionally, the mixing of animals at the slaughterhouse (more fighting) and length of waiting time at the slaughterhouse after transport (recovery to reference values) can influence results. The numbers of animals to be selected for reliable sampling can therefore depend upon whether or not the evaluation is based on animal category or per factor for each animal category.
If an insight is required into the seasonal effect (weather conditions), an evaluation should be performed spread out over at least 1 year (depending on the weather conditions this could take longer).
In the table it is shown whether much or little variation is expected between animals within each category (and whether more or fewer measurements are required for reliable results). Beef calves form a more homogenous group (breed, age, husbandry) than cull cows (breed, age, husbandry, reason for cull, condition). Bruising of meat is to be expected more with groups of animals that fight for their ranking order within the group. Several meat quality parameters have been included in the overview in the appendices. These are particularly concerned with parameters from literature in relation to stress and physical contact between animals (ranking order/fighting). Tables 9a and 9b contain five examples. If during the inspection it becomes apparent that certain parameters do not display variation, these are then replaced with alternatives.

Table 9a. Parameters (and reference values[1]) and categories of cattle and expected variation levels within category (- = low, +++ = high)

Slaughter parameter	Ref. Values	Beef calves	Rose veal calves	Beef bulls	Beef cows	Cull cows
pH		-	-	+	+++	+++
Glycogen (muscle)		-	-	+	+++	+++
Dark cutting beef	--%	-	-	+	+++	+++
Dark firm dry beef	--%	-	-	+	+++	+++
Bruising in meat		-	-	+++	+	+

[1])Reference values are specific to category, sex and only partially available and influenced by method of determination (no –international- standardization).

Table 9b. Parameters (and reference values) and categories of pig and expected variation levels within category (- = low, +++ = high)

Slaughter parameter	Ref. values	Fattening pigs	Cull sows
pH	<6.30 - >6.5	+	++
Glycogen (muscle)		+	++
Pale soft, exudative (PSE)	MOM >=100	+	++
dark, firm, dry (DFD)	pH >=6.5	+	++
Bruising in meat		++	++
Damages pig	1 (no) -4 (extreme)	++	++

A similar picture with pigs: variation between cull sows is considerably higher than between fattening pigs (age, health status).

4.3.2 Laboratory inspection of animals sampled prior to transportation

Blood samples are taken after transportation from those animals inspected and sampled prior to transportation. According to the list in table 1 this involves animals transported as a group some of which are to be exported as breeding stock. If these animals are included on the list, they will have to be sampled abroad (prescribe identical procedure). The analyses results from samples taken prior to transport are compared to those taken after transport alongside literature values in order to quantify welfare during transportation.
It is worth contemplating sampling fewer animals per group but including more groups in the evaluation to broaden the insight into variation in conditions.

Table 10a. Determination after transport (of cattle already sampled)

Parameter	Method	Ref. values	Comments
Hb		5-8	
Hematocriet		.27 - .36	
Leucocytes		5 – 10	
BHBA		< .9	
Nefa's		< .59	
Glucose		2.9 – 4.4	
Tot. Protein		60 – 90	
Creatine kinase		< 125	
Base excess	Blood gas analysis		
Saturation	Blood gas analysis		
Acidification	Blood gas analysis		
Cortisol			
Testosterone			
Progesterone			
Muscle enzymes			
Acute phase proteins			

Tabel 10b. Determination after transport (of pigs already sampled)

Parameter	Method	Ref. values	Relevance			
			piglet	gilt	Fattener	sow
Hb		6.2–8.7	*	*	*	*
Hematocriet		35-45	*	*	*	*
Leucocytes		10-18	*	*	*	*
Glucose		3.3-4.0	*	*	*	*
Tot. Protein			*	*	*	*
Creatine kinase		1000-2500 U/L	*	*	*	*
Base excess	Blood gas analysis		*	*	*	*
Saturation	Blood gas analysis		*	*	*	*
Acidification	Blood gas analysis		*	*	*	*
Cortisol		6-11 µg/100 ml	*	*	*	*
Testosterone			*	*	*	*
Progesterone			*	*	*	*
Muscle enzymes			*	*	*	*
Acute phase proteins			*	*	*	*

4.3.3 Autopsy of animals that died during transportation

Autopsy should be performed on 100 animals from each category of animal that died during transport to determine cause of death. In particular attention should be given to non-infectious mortalities. Animals are to be chosen from transports from which all pre-transportation inspection results are available. Depending on the numbers of mortalities 1 dead animal should be presented for autopsy by less than 5 deaths per category. If more animals die then approximately 20% should be presented for autopsy.
Animals that die during transportation abroad should be directly – upon arrival – submitted for autopsy (specify where to look, protocol).
An exceptional group of transporations are those where animals are transported from abroad through the Netherlands or are imported. The original situation of the animal shall probably be unknown so that evaluation of the pre-transport samples taken under Dutch conditions is impossible.
It would be interesting to compare cause of death of animals transported according to Dutch standards with those transported according to foreign standards.

4.3.4 Clinical inspection and irregularities up to 1 month after transportation

A selection is made from those animals that are transported between farms for monitoring of the clinical inspection and irregularities in health and welfare up to a month after arrival. It concerns those animals that are transported to continue their lives elsewhere: calves intended for beef production, breeding calves and older breeding stock or cattle intended for culling later. As shown in Table 1, with cattle it is often the case of an individual animal that is introduced into a herd (breeding stock) or on new farms groups of animals introduced for fattening (calves for beef production and cull cattle). Often with pigs this concerns transportation of piglets or breeding gilts in groups. The intended quantification of production[11] would appear to be impossible based on Table 11 (piglets and gilts offer a possibility for comparison with group production of other types of animals). Data collection remains restricted to mortality, abortions and numbers and reasons for treatments in relation to disease/irregularities. Health status can be deduced from the types and numbers of treatments supported by findings of the stockman.

Those animals that have at least been inspected at loading and upon arrival, will have a clinical inspection within a month of arrival (on-farm), details of irregularities are also registered.

Table 11. Production parameters (pr) of animals up to a month after transport and indication of possibility of comparison with (ve) animals not transported

Group	Intact calf		Breeding calf		Breeding heifer		Cull cow		Piglet		Gilt	
Production	pr	ve	Pr	ve	pr	Ve	pr	ve	pr	ve	pr	ve
- growth (meat)	Y	N	Y	Y	N		Y	N	Y	Y	Y	Y
- milk	N		N		Y	Y	y/n	N	N		?	
- calf/piglet	N		N		Y	Y	N		N		?	

Irregularities

- Deaths: Based on animal documentation it can be seen which animals have died within a month of arrival (often with a description of the most likely cause of death).
- Abortions: Based on animal administration it can be seen which pregnant animals have aborted within the month after arrival.
- Removal: Based on animal documentation it can be seen which animals have left the farm (earlier than intended) within a month of arrival (often with reason for removal).
- Medical treatments: Based on animal documentation it can be seen which medicines (dosage) have be administered and how often the animals have been treated within the month after arrival.

Clinical inspection

Clinical inspection such comprise the same parameters addressed during clinical inspections held on-farm prior to transportation, with additional parameters that could indicate influence from transportation. The timing of this inspection depends on the purpose of the inspection. When it is the intention to determine the differences for certain parameters for a specific time after arrival at the farm, e.g. a moment in the 3rd week after arrival. If it is the intention to indicate speed of recovery, then the inspection may be spread over several intervals.

[11] Production parameters are concerned mainly with levels of milk production of daily growth, but also health/sickness status are indicated.
Growth can be estimated from body weight upon arrival and body weight after one month at the farm. If there isn't a weighing scale available then an estimation ofthe body weight can be made based on the circumference of the breast.
Milk production and milk contents are registered on most farms by the milk control service (MPR) every 3 – 6 weeks for each cow. However, in the month after arrival on the farm there is not always a MPR collection and sampling.
In the categories breeding calves, older breeding stock and cull cattle there is the possibility of large variation in age and production. A pregnant heifer transported to a farm 6 weeks before calving, shall especially show an increase in body weight due to growth of the calf. A cull cow at the end of lactation that is transported to a farm for fattening on grass, will primarily production meat, unless still lactating, in which case it will have to produce both meat and milk.
In many cases production after transportation to a different farm is not to be compared with production prior to transport on the original farm. An impression of these differences has to be compared on the basis of expert opinion.

Table 12a. Parameters for clinical inspection of cattle in the period up to 1 month after arrival

Parameter	Method	Ref. values	Comments
Body score	ASG	>1.5	
Wounds/Swelling	ASG	< 6 cm	
Fractures		None	
Dung consistency	Welfare Quality	>1	
Locomotion	Manson&Leaver	<4	
Deep seated eyes	Welfare Quality	No	
Colour mucous membranes	Welfare Quality	Rose	
Alertness	Welfare Quality	Alert/active	
Discharge eyes, nose, vulva	Welfare Quality	None	
Shallow breathing	Welfare Quality	None	
Behaviour (ranking order/fighting)	Welfare Quality	Score	
Flight test	Welfare Quality	Score	
Rumen fill	Welfare Quality	Score	
Rumination activity	Welfare Quality	>	
Obviously ill	If thought sick then examine further:		
- Body temperature	Measure	38.6 ±0.5	
- heart beat	Count	48-84	
- respiration frequency	Count	26-50	

Table 12b. Parameters for clinical inspection of pigs in the period up to 1 month after arrival

Parameter	Method	Ref. values	Relevance	
			piglet	gilt
Body score			*	*
Wounds			*	*
Fractures		None	*	*
Locomotion			*	*
Deep seated eyes		No	*	*
Colour mucous membranes		Rose	*	*
Alertness		Alert/active	*	*
Discharge eyes, nose, vulva		None	*	*
Scheve kop		Balanced	*	
Head posture		Flat	*	
Abdominal breathing		None	*	*
Behaviour (ranking order/fighting)			*	*
Obviously ill	If thought sick then examine further:			
- body temperature	Measure		*	*
- heart beat	Count		*	*
- respiration frequency	Count		*	*

5 Recommendations / development of a monitoring protocol

It is possible to formulate monitoring protocols for animal welfare during transportation based on the observations suggested. These protocols should be adapted to animal categories, possibly even gender, presenting as little as possible burden to the animal and the process, and be capable of presenting a clear appraisal of whether or not an animal is fit to travel or to continue its journey. The following protocols are proposed for various animal categories:

- On-farm inspection: Clinical inspection together with laboratory analyses for groups of animals (farm or assembly point),
- At loading: clinical inspection during loading (farm or assembly point),
- In compartment during long journeys, using equipment (in vehicle)
- During resting period on long journeys: clinical inspection, eventually with equipment (in vehicle),
- At unloading: clinical inspection (farm, slaughterhouse or assembly point),
- During unloading/loading on long journeys (assembly point, resting place).

The protocols should contain reference values (or ranges) that will allow a reliable estimation of the fitness of the animal to travel. In these protocols it is recommended that:

- Those parameters included in the protocol should have reference values that bare relevance to the ability to indicate fitness to travel and fitness during travel.
- Protocol should contain an indication of the importance of each parameter (and degree of discrimination).

Additional research is essential to develop protocols that provide a clear and reliable appraisal of fitness to travel and fitness during transport. This research should have the following aims:

- Determination and /or improved definition of reference values for different animal categories and where necessary for gender differences.
- Evaluation of proposed inspections and eventual adjustments (and re-evaluation).
- Co-ordination with foreign authorities because some protocols (compartment inspection, loading, unloading/loading) will be performed abroad.

It is prosposed that an evaluation should be performed at the end point of the transportation (short and long journeys). On long journeys some of the observations necessary for the evaluation will be performed at resting/assembly points. This will include parameters based on observations of the animal and conditions of transport.

- Slaughter parameters, laboratory analyses of meat.
- Laboratory analyses for comparison of values prior to and after transportation (end point and during long journeys).
- Autopsy of animals that died during transportation.
- Clinical inspection and irregularities within the first month after arrival at the farm of destination.

In order to obtain a rapid response for those animals that are transported often and over long distances these should be inspected in groups. This is particularly the case for exported animals. With cattle this concerns mainly heifers and calves, with pigs piglets and fatteners. Large numbers of lambs and goats are also exported. Imports of large numbers of fattening pigs, intact calves, sheep, goats and horses involves transportation.

Journeys over long distances are considered to be more of a burden to the animals than those over short distances. Long journeys, particularly in the Netherlands, involve mainly animals for export. It is strongly recommended that research into fitness to travel and fitness during transport should be performed throughout the EU with co-ordination of the results. Clear and concise legislation prevailing for the whole of the EU will help to improve animal welfare and discourage attempts to avoid the law.

Schedule for the types of inspection and evaluation to determine fitness to travel and fitness during transport (with reference to appropriate table with parameters)

Inspection	**Animals**	**Timing**	**Fitness to travel**	**Fitness during transport**	**Evaluation Testing parameters Development ref. values**
On-farm, Clinical (table 2)	Groups	x days prior to transport	*	na	
On-farm, laboratory (table 3)	Groups	x days prior to transport	*	na	Laboratory, Previously sampled animals (table 10)
	Groups	On continuation of journey	na	*[12]	Laboratory, Previously sampled animals (table 10)
Loading (table 4)	All animals	At beginning of transport	*	na	
	All animals	At beginning of long transport	na	*	
Compartment (table 6)	Groups	During long transport	na	*	laboratory, previously sampled animals (table 10)
Resting place (table 7)	Groups	During resting periods on long journeys	na	*	laboratory, previously sampled animals (table 10)
Unloading (table 5)	Groups	end transport	*	na	autopsy dead animals
			*		laboratory, previously sampled animals (table 10)
			*		Slaughter results (table 9)
			*		clinical inspection <1 mn (table 12)
(table 8)	Groups	End of long period of transport	na	*	autopsy dead animals
				*	laboratory, previously sampled animals (table 10)

Na = not applicable

[12] Rapidly available analysis data can be used to determine fitness during travel.

6 Conclusions

- Literature does not provide support for division of transport into long and short based on 8 hour periods. Transport within the Netherlands is generally short.
- In terms of practicability determination of fitness to travel for a proposed journey should be possible without the use of equipment.
- Whether or not an animal is fit to travel depends on the animal and the conditions of transportation.
- It is assumed that transports are performed in accordance with the decree on transport of animals. Climate conditions may lead to inclusion of extra analyses (e.g. for young animals with poor themoregulation and high atmospheric temperatures).
- It should be ascertained as to whether or not fitness to travel is specific to individuals, groups or gender. For certain sensitive groups of animals (e.g. young or pregnant animals) requirements/demands could be recognized for the group, in other circumstances assessment should be made of the individual animal.
- Often during export, individual animals are collected from several different farms at an assembly station for further transportation abroad. It remains unclear whether transportation begins at the farm of origin or at the assembly station.
- There is always an inspection of animals intended for export or whenever the expected journey time is long. Attention should be paid (in subsequent research) to these groups since it is here where the greatest variation is expected.
- Importation of animals, is possible without international agreement, assessment of fitness to travel is then only available at assembly points in the Netherlands and at the destination during unloading.
- There is a set of animal based parameters proposed that is capable of determining whether or not an animal is fit to travel on the intended journey. This set of parameters for clinical inspection of different categories of agricultural livestock may vary for young or old animals.
- Especially with cull dairy cows there is a large range in age, reason for culling and the (final)destination. This group contains young as well as old animals that are removed due to disappointing production levels, animals with sub-clinical mastitis (high cell count), crippled animals and barren animals (but further healthy). These animals are mostly sent direct for slaughter but occasionally are sent to alternative farms to be fattened for several months prior to slaughter.
- Variation is large in the category cull sows (and boars). These are mainly exported to foreign slaugtherhouses.
- Reference values for parameters to indicate changes on the animal during transport (i.e. different forms of stress, lack of water, fasting) are not always evident and require further evaluation.
- Research must examine the relevance of clinical parameters to determine fitness to travel and their limitations. Therefore, clinical and laboratory analyses (blood, meat) are determined and related to those parameters that can be assessed during transport.

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Appendices

Appendix 1a. Possible parameters cattle

Value	Criteria	Value limits	Relevance	Chance of success	Further development/research	Costs	Practicability	Invasion of animal	Suitabiity fit for travel	Suitability fitness during transport
Clinical inspection										
	Respiration									
	Respiration frequency	26-50	+	+	-	-	+	-	+	-/+
	Increase in respiration rate		+	+	-	-	+	-	+	-/+
	Irregular breathing		+	+	-	-	+	-	+	-/+
	Forced breathing		+	+	-	-	+	-	+	-/+
	Coughing		+	+	-	-	+	-	+	-/+
	Sneezing		+	+	-	-	+	-	+	-/+
	Pulse (manual, electronic)									
	Heart beat rate	48-84	+	+		-	-	-	+	-
	Heart beat rate variability			+						
	Recovery to normal heart beat rate			+						
	Recovery to normal heart beat rate variability			+						
	Temperature (manual, electronic)									
	Body temperature	38.3	+	+	-	-	-	-	+	-/+
	Temperature extremes		+	+	-	-	-	-	+	-
	Shivering		+	+	-	-	-	-	+	-
	panting/protruding tongue		+	+	-	-	-	-	+	-
	Sweating		+	+	-	-	-	-	+	-
	Skin / hair cover / horn tissue									
	Damages		+	+	+	+	+	-	+	+
	Turgor (emaciation)		+	+	+	+	+	-	+	-
	De-horned	Healed	+	+	-	-	+	-	+	
	Behaviour/ posture/ mobility (observation)									
	Ease of stance		+	-/+				-	-	-
	Laying down		+	-/+				-	-	-
	Slipping		+	+				-	-	-
	Locomotion scores/lameness	<3.5	+	+				-	+	-
	Hoof scores		-	-				-	-	-
	Long/full hooves							-	+	-
	Balance		+	+				-	+	+
	Vocalizations		-	-/+				-	-	-
	Avoidence test (distance)		+	-/+				-	-	-

Fighting/ranking order		+	+				-	-	-
Obvious (clinical) irregularities									
Swollen joints		+	+				-	-	-
Deeply set eyes		+	+				-	-	-
Wounding		+	+				-	+	+
Neglect: colour/sheen/cleanliness		+	+				-	+	
Form of stomach		+	+				-	+	
Discharge: eyes/nose/vulva	None	+	+				-	+	
Metabolism: dung score	3	-/+	-/+				-	+	
Diarrhoea: dung consistency	>1	+	+				-	+	
Rumen fill (score)		+	+				-	+	
Rumination activity		+	-/+				-	+	
Recently castrated	Healed	+	+				-	+	
Recently calved animals	>48 h	+	+				-	+	
Scabies/fleas/…	None	+	+				-	+	
Full/tight udder	No	+	+				-	+	
Panicing/fearful/nervous animals		+	+				-	-	
Temperament		+	-/+				-	-	
Eating time after transit		+	-/+				-	-	
Drinking after transit		+	-/+				-	-	-
Time budgets		+	-/+				-	-	-
Blood pressure		-	-/+				-	-	-
Alertness/vigilance		+	+				-		
Abortion		+	+						
Body weight									
Bwt in relation to age => BCS	2<	+	+				-	+	-
Condition		-/+	-/+				-	-	-
Weight loss (BCS = 1)	1	+	+				-	-	-
Mucous membranes									
Colour	+	+					-	+	
Capillary refill time		+					-	+	
Moistness	+	+					-	+	
Lymph nodes									
Palpalation							-	-	
Blood values									
Virological inspection									
Red blood film									
Hb	5-8						+	+	+
Ht	.27-.36						+	+	+
White blood film									
Leucocytes	5-10	+					+	+	+
Basofile	<2	-					+		
Eosinefile	<10	-					+		
Neutrofile	25-60	+					+	+	+
Monocytes	<5						+		
Lymphocytes	40-70	+					+	+	+
Lymphocyte B adrenoreceptor							+	+	+
Lymphocyte glucoreceptor							+	+	+
Acidification									

Lactate		+					+	+	+
pH		+					+	+	+
Osmolariteit		+					+		
Vasopresine		+					+		
Fibrinogen							+		
Ceruloplasmine							+		
Haptoglobine							+		
Noradrenaline							+		
Base excess							+	+	+
Oxygen									
O_2-saturation							+	+	+
Electrolytes									
Na							+		
K							+		
Ca							+		
Total protein / electrophoresis									
TP	60-90	+					+	+	+
Protein catabolism		+					+	+	+
Acute phase proteins		+					+	+	+
Enzymes									
ALP	<225						+		
ALAT							+		
AST	30-56						+		
CPK (creatine kinase)	<125	+					+	-	+
gGt	<30						+		
GLDH	<15						+		
GSH-Px	120-600	-					+		
LDH	1250-2150						+		
Pepsinogen	1.5-3.5						+		
Energy status									
Nefa's/free fatty acids	<0.59	+					+		
BHBA	<0.9	+					+		
Urea	3.3-6.6	+					+		
Glucose	2.9-4.4	+					+		
Stress hormone									
Cortisol		+					+		+
Natural killer cells		+					+		
IgF1		+					+		
IgA		-					+		
Thyroid hormones: T3		+					+		
T4		+					+		
fT3		+					+		
fT4							+		
Growth hormones / IGF1/IGFBP		+					+		
Testosterone							+		
Progesterone							+		
Fattening liver									
BHBA	< 0.9	+					+		
Biliribune	< 7	+					+		
Trace elements									
Alc Phos	<225	-	-				+		
Cu	7.5-18	-	-				+		

Zn	12-23	-	-				+		
Cholesterol									
Creat									
Creatine	88-240	+	+				+		
Excessive activity									
Norepinephrine		-	-				+		
Meat									
Dark firm beef (DFB)		-					-		+
Dark culling Beef (DFB)		-					-		+
pH							-		+
Glycogen							-		+
Urine									
Osmolarity		**+**	**-**				**-**		
Specific gravity		-	-				-		
pH		-	-				-		
Ketones		-	-				-		
Nitrite		-	-				-		
Urobilirubin		-	-				-		
Sediment		-	-				-		
Urea		+	-				-		
Magnesium		+	-				-		
Sodium		+	-				-		
Volume		+	-				-		
Faeces									
Parasites									
Stomach/intestine worms							-/+		-
Liver fluke							-/+		-
Coccidiosis							+		-
Others									
Water use		+	+				-		
Drinking after unloading		+	-				-		+
Somatic cell count		-	-				-		
Success insemination		-	-				-		
Dunging frequency		+	-			-	-		
Saliva IgA									

Appendix 1b possible parameters weaned piglets

Value	Criteria	Value limits	Relevance	Chance of success	Further development/research	Cost	Practicability	Invasion of animal	Suitability fit for travel	Suitability fit during transport
Clinical inspection										
Respiration										
+/-	Breathing frequency	25-40		+	+		+/-	+	+/-	-
	Abdominal breathing									
+	Sneezing		+	+	+	+	+	+	+	+
+	Other sounds		+	+	+	+	+	+	+	+
+	Coughing		+	+	+	+	+	+	+	+
Pulse										
+/-	Manual	90-100		-	+	+	-	+	-	-
+	Heart beat meters (polar, ecg)			+	-	-	+/-	-/+	+/-	+/-
+	Heart beat rate			+	-	-				
?	Heart beat rate variability			?	-	-				
?	Recovery time to normal heart beat			?	-	-				
?	Recovery time to normal heart beat rate variability			?	-	-				
Temperature										
+/-	Rectal	39,3		-	+	-	-	+	-	-
?	Ear			+	-	-	+	-	?	?
?	Chips			+	-	-	+	-	?	?
Skin / hair cover / horn tissue										
+	Colour, thickness,upright, long hair		+	+	+	+	+	+	+	+
+	Damages		+	+	+	+	+	+	+	+
-	Turgor (emaciation)		+	-	+		-	+	-	-
Behaviour/posture/gait										
+	posture (huddling, sternal/lateral laying)		+	+	+		+	+	+	+
+/-	Animals laying down		+/-	-	+			+	-	-
+	Ease of stance, sitting down		+	+	+		+	+	+	+
+	Slipping		-	-	+			+	-	
+	Locomotion scores		+	+	+		+	+	+	+
+	Foot scores		-	-	+			+		
	Alertness									
	% lying down during transit	?								
Obvious clinical irregularities										
+	Crooked head (otitis media/externa, meningitis)		+	+	+	+	+	+	+	+

+	Lameness		+	+	+	+	+	+	+	+
+	Swollen joints		+	+	+	+	+	+	+	-
+	Deeply set eyes		+	+	+	+	+	+	+	+
	Eye discharge, tear marks									
	Nose discharge									
+	Wounding		+	+	+	+	+	+	+	+
+	Condition scores		+	+	+	+	+	+	+	-
+	Cachexie		+	+	+	+	+	+	+	-
+	Neglect		+	+	+	+	+	+	+	-
	Dung/faeces									
Body weight										
+/-		15-25	+/-	+	+	+	+	+	+	+
?	Weight loss	<10%	+	+	-	-	+	+	+	+
Mucous membranes										
+	Colour, blisters		+	+	+	-	-	+	+	+
	capillary refill time (CRT)		+	+	+			+	+	+
	Moistness		+	+	+			+	+	+
Lymph nodes										
+/-	Palpalation									
Blood values										
Virological inspection										
Red blood film										
	Hb		+	-	+	-	-	-	+	+
	Ht		+	-	+	-	-	-	+	+
White blood film										
	Leuco's		?	-	+	-	-	-	+	?
	Diff		?	-	+	-	-	-	+	?
Antibodies										
	IgG	?	?							
	IgM	?	?							
	IgA	?	?							
Acidification										
	Lactate		+	+	-	-	+	-	+	+
	pH		+	+	-	-	+	-	+	+
Oxygen										
	O_2-saturation		+	-	-	-	-	-	?	?
Electrolytes										
	Na					-				
	K					-				
	Ca					-				
Total protein/ electrophoresis										
						-				
Enzymes										
	ALP					-				
	ALAT									
	AST									
	CPK									
	gGt									

GLDH									
GSH-Px									
LDH									
Pepsinogen									
Energy status									
nefa's		-							
BHBA		-							
Urea		-							
Stress hormone									
Cortisol		+							
Liver fattening									
		-							
Trace elementen									
Cholesterol									
Creatine									
		?	?	-					
Glucose									
		?	?	-					
Creat kinase									
		?	?	-					
Excessive activity									
Norepinephrine		-	?						
Urine									
Ca									
Specific gavity		+	-	+	-	-	-	-	+
Creat,									
pH									
Glucose									
Ketones									
Nitrite									
Bilirubin									
Urobilinogen									
Sediment									
Urea									
Magnesium									
Faeces									
BO									
Virus									
Other									

Appendix 1c Possible parameters fattening pigs

Value	Criteria	Value limits	Relevance	Chance of success	Further development / research	Cost	Practicability	Invasion of animal	Suitability fit for travel	Suitability fit during transport
Clinical inspection										
Respiration										
	Frequency	25-35	+	+	+	+	+/-	+	+/-	-
+	Sneezing		-	-	+				-	-
+	Other sounds		+	+	+	+	+	+	+	+
+	Coughing		+	+	+	+	+	+	+	+
	abdominal breathing									
Pulse										
	Manual	75-85		-	+	+	-	+	-	-
	Heart beat meters (polar, ecg)			+	-	-	+/-	-/+	+/-	+/-
	Heart beat rate			+	-	-	+/-	-/+	+/-	+/-
	Heart beat rate variability			?	-	-	?	?	?	?
	Recovery time to normal heart beat			?	-	-	?	?	?	?
	Recovery time to normal heart beat rate variability			?	-	-	?	?	?	?
Temperature										
	Rectal	38,8		-	+	-	-	+	-	-
	Ear			+	-	-	+	-	?	?
	Chips			+	-	-	+	-	?	?
Skin / Hair cover/ horn tissue										
	Observation		+	+	+	+	+	+	+	+
	Damages		+	+	+	+	+	+	+	+
	Turgor (emaciation)		+	-	+		-	+	-	-
Behaviour/posture/ gait										
	Observation		+	+	+	+	+	+	+	+
	Lying down		+/-	-	+	+	-	+	-	-
	Ease of stance		+	+	+	+	+	+	+	+
	Slipping		+	+	+	+	+	+	+	+
	Locomotion scores		+	+	+	+	+	+	+	+
	Foot scores		-	-	+	+		+		
	% lying during transit	?								
Obvious clinical irregularities										
	Wounds eye/tail		+	+	+	+	+	+	+	+
	Lameness		+	+	+	+	+	+	+	+
	Swollen joints		+	+	+	+	+	+	+	-

	Deeply set eyes		+	+	+	+	+	+	+	+
	Wounding		+	+	+	+	+	+	+	+
	Condition scores		+	+	+	+	+	+	+	-
	Cachexie		+	+	+	+	+	+	+	-
	Neglect		+	+	+	+	+	+	+	-
	Nose discharge									
Body weight										
	Weight		+/-	+	+	+	+	+	+	+
	Weight loss		+	+	-	-	+	+	+	+
Mucous membranes										
+	colour, blisters		+	+	+	-	-	+	+	+
	capillary refill time (CRT)		+	+	+			+	+	+
	Moistness		+	+	+			+	+	+
Lymph nodes										
	Palpalation		-	-	+		-	+	-	-
Blood values										
Virological inspection										
Red blood film										
	Hb		+	-	+	-	-	-	+	+
	Ht		+	-	+	-	-	-	+	+
White blood film										
	Leuco's		?	-	+	-	-	-	+	?
	Diff		?	-	+	-	-	-	+	?
Antibodies										
?	IgG	Together indicate possibility of infection/ lowering resistence	?							
?	IgM		?							
?	IgA		?							
Acidification										
	Lactate		+	+	-	-	+	-	+	+
	pH		+	+	-	-	+	-	+	+
Zuurstof										
	O_2-saturation		+	-	-	-	-	-	?	?
Electrolyten										
	Na				-					
	K				-					
	Ca				-					
Total protein / electrophoresis										
					-					
Enzymes										
	ALP				-					
	ALAT									
	AST									
	CPK									
	gGt									
	GLDH									
	GSH-Px									
	LDH									
	Pepsinogen									

Liver fattening									
		-							
Trace elements									
Cholesterol									
Creat									
		?	?	-					
Glucose									
		?	?	-					
Creat kinase									
		?	?	-					
Excessive activity									
Norepinephrine		-	?						
Urine									
Ca									
Specific gravity		+	-	+	-	-	-	-	+
Creat,									
pH									
Glucose									
Ketones									
Nitrite									
Bilirubin									
urobilinogen									
Sediment									
Urea									
Magnesium									
Other									

Appendix 1d Possible parameters breeding gilts

Method	Value	Criteria	Value limits	Relevance	Chance of success	Further development / research	Cost	Practicability	Invasion of animal	Suitability fit for travel	Suitability fit during transport
Clinical inspection											
		Respiration									
		Frequency, type	25-35		+	+		+/-	+	+/-	-
	+	Sneezing		-	-	+	+	-	+	-	-
	+	Other sounds		+	+	+	+	+	+	+	+
	+	Coughing		+	+	+	+	+	+	+	+
		abdominal breathing									
		Pulse									
		Manual	75-85		-	+	+	-	+	-	-
		Heart beat meters (polar, ecg)			+	-	-	+/-	-/+	+	+
		Heart beat rate			+	-	-				
		Heart beat rate variability			?	-	-				
		Recovery time to normal heart beat			?	-	-				
		Recovery to normal heart beat rate variability			?	-	-				
		Temperature									
		Rectal	38.8		-	+	-	+	+	-	-
		Ear		+	+	-	-	+	-	?	?
		Chips		+	+	-	-	+	-	?	?
		Skin / hair cover / horn tissue									
		Observation		+	+	+	+	+	+	+	+
		Damages		+	+	+	+	+	+	+	+
		Turgor (emaciation)		+	-	+		-	+	-	-
		Behvaiour/posture/gait									
		Observation		+	+	+	+	+	+	+	+
		Lying down		+/-	-	+	+	-	+	-	-
		Ease of stance		+	+	+	+	+	+	+	+
		Slipping		-	-	+	+	+	+	-	
		Locomotion scores		+	+	+	+	+	+	+	+
		Foot scores		-	-	+	+	+	+	-	-
		% lying during transit	Reason for lying down?								
		Obvious clinical irregularities									
		Observation		+	+	+	+	+	+	+	+
		Lameness		+	+	+	+	+	+	+	+
		Swollen joints		+	+	+	+	+	+	+	-
		Deeply set eyes		+	+	+	+	+	+	+	+

Wounding		+	+	+	+	+	+	+	+
Condition scores		+	+	+	+	+	+	+	-
Cachexie		+	+	+	+	+	+	+	-
Neglect		+	+	+	+	+	+	+	-
Nose discharge									
Body weight/condition									
Weight		+/-	+	+	+	+	+	+	+
Weight loss	<10%	+	+	-	-	+	+	+	+
Mucous membranes									
+ Colour, blisters		+	+	+	-	-	+	+	+
capillary refill time (CRT)		+	+	+			+	+	+
Moistness		+	+	+			+	+	+
Lymph nodes									
Palpalation									
Blood values									
Virological inspection									
Red blood film									
Hb		+	-	+	-	-	-	+	+
Ht		+	-	+	-	-	-	+	+
White blood film									
Leuco's		?	-	+	-	-	-	+	?
Diff		?	-	+	-	-	-	+	?
Antibodies									
? IgG									
? IgM									
? IgA									
Acidification									
Lactate		+	+	-	-	+	-	+	+
pH		+	+	-	-	+	-	+	+
Oxygen									
O_2-saturation		+	-	-	-	-	-	?	?
Electrolytes									
Na		?		-					
K		?		-					
Ca		?		-					
Total protein / electrophoresis									
		?		-					
Enzymes									
ALP				-					
ALAT									
AST									
CPK									
gGt									
GLDH									
GSH-Px									
LDH									
Pepsinogen									
Liver fattening									
		-							
Trace elements									

Cholesterol									
Creat									
		?	?	-					
Glucose									
		?	?	-					
Creat kinase									
		?	?	-					
Excessive activity									
Norepinephrine		-	?						
Urine									
Ca									
Specific gravity		+	-	+	-	-	-	-	+
Creat,									
pH									
Glucose									
Ketones									
Nitrite									
Bilirubin									
urobilinogen									
Sediment									
Urea									
Magnesium									
Other									

Appendix 1e Possible parameters cull sows

Value	Criteria	Value limits	Relevence	Chance of success	Further development / research	Cost	Practicability	Invasion of animal	Suitability fit for travel	Suitability fit during transport
Clinical inspection										
Respiration										
	Frequency	13-18	+	-	+	+	+/-	+	+/-	-
+	Sneezing		-	-	+		+	+	-	-
+	Other sounds		+	+	+	+	+	+	+	+
+	Coughing		+	+	+	+	+	+	+	+
	Abdominal breathing									
Pulse										
	Manual	70-80	+	-	+	+	-	+	-	-
	Heart beat meters (polar, ecg)		+	+	-	-	+/-	-/+	+/-	+/-
	Heart beat rate		+	+	-	-	+/-	-/+	+/-	+/-
	Heart beat rate variability		?	?	-	-	+/-	-/+	+/-	+/-
	Recovery time to normal heart beat		?	?	-	-	+/-	-/+	+/-	+/-
	Recovery time to normal heart beat rate variability		?	?	-	-	+/-	-/+	+/-	+/-
Temperature										
	Rectal	38,4	+	-	+	-	-	+	-	-
	Ear		+	+	-	-	+	-	?	?
	Chips		+	+	-	-	+	-	?	?
Skin / hair cover / horn tissue										
	Observation		+	+	+	+	+	+	+	+
	Damages		+	+	+	+	+	+	+	+
	Turgor (emaciation)		+	-	+		-	+	-	-
Behaviuor/posture/gait										
	Observation		+	+	+	+	+	+	+	+
	Lying down		+/-	-	+	+		+	-	-
	Ease of stance		+	+	+	+	+	+	+	+
	Slipping		+	-	+	+		+	-	
	Locomotion scores		+	+	+	+	+	+	+	+
	Foot scores		+	+	+	+	+	+	+	+
	% lying down during transport	Reason for lying down								
Obvious clinical irregularities										
	Udder		+	+	+	+	+	+	+	+
	Lameness		+	+	+	+	+	+	+	+
	Swollen joints		+	+	+	+	+	+	+	-
	Deeply set eyes		+	+	+	+	+	+	+	+

Wounds		+	+	+	+	+	+	+	+
Condition scores	1-6	+	+	+	+	+	+	+	-
Cachexie		+	+	+	+	+	+	+	-
Neglect		+	+	+	+	+	+	+	-
Nose discharge									
Vulva discharge									
Diseases of swine									
Body weight									
Weight		-	-	+	+	+	+	-	-
Weight loss	<10%	+	+	-	-	+	+	+	+
Mucous membranes									
Colour		+	+	+	-	-	+	+	+
capillary refill time (CRT)									
Moistness									
Lymph nodes									
Palpalation									
Blood values									
Virological inspection									
Red blood film									
Hb		+	-	+	-	-	-	+	+
Ht		+	-	+	-	-	-	+	+
White blood film									
Leuco's		?	-	+	-	-	-	?	?
Diff		?	-	+	-	-	-	?	?
Antibodies									
? IgG									
? IgM									
? IgA									
Acidification									
Lactate		+	+	-	-	+	-	+	+
pH		+	+	-	-	+	-	+	+
Oxygen									
O_2-saturation		+	-	-	-	-	-	?	?
Electrolytes									
Na				-					
K				-					
Ca				-					
Total protein / electrophoresis									
				-					
Enzymes									
ALP				-					
ALAT									
AST									
CPK									
gGt									
GLDH									
GSH-Px									
LDH									
Pepsinogen									

Liver fattening									
		-							
Trace elements									
Cholesterol									
Creat									
		?	?	-					
Glucose									
		?	?	-					
Creat kinase									
		?	?	-					
Excessive activity									
Norepinephrine		-	?						
Urine									
Ca									
Specific gravity		+	-	+	-	-	-	-	+
Creat,									
pH									
Glucose									
Ketones									
Nitrite									
Bilirubin									
urobilinogen									
Sediment									
Urea									
Magnesium									
Others									

Appendix 2a. Parameters used to quantify risks to cattle during transit

Value Fasting	Method	Literature	Change in measurement value	Animal category	Duration transport
+	Rumen fill				
+	Rumination frequency				
+	Body weight	Jones et al,1988, Warris,1990, Scheafer et al, 1997,	Depending on level of fasting: 0.75% of body weight per day; 3-11%	Bulls	24, 48 and 72 hours without food
+	Body weight	Gallo et al, 2003	8.5 kg	Bulls	3 h v 16 h
+	Consistency dung				
+	Blood glucose	Krawczel, 2007	Decrease	Lambs	22 h (with or without a break)
+	blood urea	Krawczel, 2007	Increase	Lambs	22 h (with or without a break)
+	creatine	Krawczel, 2007	Decrease	Lambs	22 h (with or without a break)
50-10000	creatine kinase	Schmeiduch, 2002, Pettiford et al, 2007	heifers: increases during loading, constant during transit, bulls/oxen: large variation	heifers/bulls/oxen	Up to 29 hours
+	Free fatty acids	Jarvis, 1996	Increase is higher as time since last meal increases	Cattle	
400-1600	Nefa	Schmeiduch, 2002	Remains above 600 umol/l, increases towards end of transport	heifers/bulls/oxen	Up to 29 hours
+	Total bilirubin	Krawczel, 2007	Decrease	Lambs	22 h (with or without a break)
	Maintenance critical body temperature	Schrama et al, 1993	Calves have difficulty	Calves	
+	Groeihormoon	Moberg, 2000			
+	IGF-1	Moberg, 2000			
+	Insulin-like growth factor binding proteins IGFBP)	Davis, 2006	Increase	Fish	
+	Heat production	Freetly, 2006	Decrease	Cattle	
+	dark cutting beef (DBF)	Crouse et al, 1984	neemt toe bij lange onthouding	Cattle	
	Glycogen (muscle)	Immonen, 2000	breed, season, temperament	Bulls ready for slaughter	5 – 5.5 hours
+	Dunging frequency (number dung heaps in vehicle)				

+	Eating time after transport	Genswein et al, 2007	More eating time not conditioned	220 kg oxen	Conditioned/not conditioned, with 2.7 /15 h transport
.4-.9	Beta-hydroxy butyric acid	Schmeiduch, 2002	With heifers a few animals above 1mmol/l at end of transport, bulls/oxen none.	heifers/bulls/oxen	Up to 29 hours
	Body condition	Fisher et al, 2009	Old cows in poor condition: more deaths	Cattle	
No water					
+	registration water use in vehicle				
+	Turgor				
+	Deeply set eyes				
+	Dry mucous membranes, colour mucous membranes				
	Drinking after loading	Jarvis, 1996, Lambooy&Hulshegge, 1988)	often/more drinking and lying down more often	Cattle	longer journeys
	Free fatty acids	Jarvis, 1996	Increase (dehydration)		
+	Body weight	Jones et al, 1988, Warris, 1990, Scheafer et al, 1997	Depending on level of fasting: 0.75% of body weight per day; 3-11%	cattle	
	Urine volume	Islam, 2004	Decrease 87%	Rats	
15-5-12.5	blood urea nitrogen	Pettiford et al, 2008	no evidence	300 kg oxen	6 h
?	Vasopressine	Ramsay, 1991	Increase	dogs	
?	Drinking water test				
+	Dung consistency (stress?)				
	Next to water trough after transport	Genswein et al, 2007	More time by water not conditioned	220 kg oxen	Conditioned/not conditioned, with 2.7 /15 h transport
60-75	normal protein	Schmeiduch, 2002	Constantly between 60 to 80 g/l, for heifers as well as bulls/oxen	heifers/bulls/oxen	Up to 29 h
137-147	Sodium	Schmeiduch, 2002	With water shortage higher than 145mmol/l,	heifers/bulls/oxen	Up to 29 h
.30-.39	Haematocriet	Schmeiduch, 2002	0.25 0 0.35 standard: almost no increase in heifers, higher at the end in bulls/oxen	heifers/bulls/oxen	Up to 29 h
+	Haematocriet and haemoglobin	Lambooy&Hulshegge, 1988	No significant differences between before and after transport	5 mths gestating heifers	25 h with 5 h rest

+	Serum osmolarity, haematocriet, haemoglobin, normal protein	Pettiford et al, 2008	Small increase, restart after resting period	300 kg oxen	6 h
Disturbance of normal behaviour					
+	daily time budgets, circadian pattern of rest and activity (e.g. time laying down)				
+	Blood pressure	Ogawa, 2003	Increase	human	No loss of sleep
+	vigilance (routine scanning of environmet)	Moberg, 2000		Cattle	
	fighting/ranking order			Cattle	
	Living space	Eldridge et al, 1988, Kennedy 1987	Calves lie down more, less free space results in less stress with older cattle	Cattle	
Thermoregulation					
+	Temperature registration in vehicle	Randall, 1993	max 30 degrees C by adult cattle	Cattle	
+	Shivering	Schrama et all, 19929,193	Young calves are sensitive to cold and older cattle more sensitive to heat	Cattle	
+	Panting				
+	tongue hanging out/open mouth				
+	Sweating				
	Outside temperature	Cave et al, 2005	More deaths during long journeys	Intact calves	275 km
Injuries					
+	Bruising of meat	Tarrant et al, 1992	Increases by higher housing density	600 kg de-horned HF bulls	
	pH positive correlation with bruising	MacNally&Warris, 1996	Increases as transit rime increases	Cattle	
+	dark cutting beef (DBF)	Warris, 1990	Increases with longer journeys/ regrouping	Cattle	
+	Dark firm dry beef (DFB)	Warris, 1990	Increases with longer journeys/ regrouping	Cattle	
+	Vulva injuries			Cattle	
+	Shedding horn			Cattle	
+	Lameness			Cattle	
	Skin damage	Lambooy&Hulshegge, 1988	Less when transported loose	5 mths gestating heifers	
	Skin damage	Eldridge&Winfield, 1988	Depending on space allowance		
Other sources of stress resulting from companion animals, environment, loading/unloading, vibration, limited ventilation, limited space, shipping fever (BRD), gene expression					
+	Heart beat	Knowles, 1999, Dickens et al, 2010	Increased	Cattle, fish	
	Breathing frequency	Knowles, 1999	Increased	Cattle	

+	Behaviour				
	less stress, lower pH meat	Mounier et al, 2006	less stress, higher pH	17 months bulls	3.5 hours
40-160	Heart beat	Gebresenbet&Eriksson, 1998	Decrease	Cows	2 – 7 hrs
178-271	Fibrinogen	Arthington et al, 2003, 2008	Differences	266 kg calves	3 hrs
19.6-32.9	Ceruloplasmin	Arthington et al, 2003, 2008	Differences	266 kg calves	3 hrs
4.6-13.4	Haptoglobin	Arthington et al, 2003, 2008	Differences	266 kg calves	3 hrs
24.6-41.4	Cortisol	Arthington et al, 2003, 2008	Differences	266 kg calves	
?	Body temperature	ormal , 1999	Increase	Cattle	
?	cortisol, glucose, creatine kinase, lactate	Maria et al, 2004	Loading worse than unloading	500 kg bulls	27 – 405 minutes
?	Turning round, slipping, falling, fighting,refusals, vocalizations	Maria et al, 2004	Loading worse than unloading	500 kg stieren	27 – 405 minutes
+	HRV	Von Borell, 2001	Non invasive measurement		
100-130	Heart beat	Jacobson&Cook, 1998	Decreases at acclimatization	6 wks calves	3 times 40 minutes
+	Dark cutting Beef (DCB)	Warriss, 1990	Increases by mixing young bulls	Young bulls	
+	Heart beat recovery to base value				
?	Motivation test (fear, exploration, Normal zero)				
+	Cortisol	Knowles 1999, Dickens et al, 2010	Increase		
22-31	Cortisol	Odore et al, 2004	increase (return to normal after 24 hours)	6 mths old calves	14 hr transport
.21-.45	Noradrenalin	Odore et al, 2004	increase (return to normal after a week)	6 mnd oude kalveren	14 hr transport
77-39	lymphocyte B-adrenorecepetor	Odore et al, 2004	increase (return to normal after 24 hours)	6 mnd oude kalveren	14 hr transport
16-4	Lymphocyte glucoreceptor	Odore et al, 2004	increase (return to normal after 24 hours)	6 mnd oude kalveren	14 hr transport
23.7-30.3	Cortisol	Genswein et al, 2007	Higher during long journeys	220 kg oxen	conditioned/ not conditioned, with 2.7 /15 hr transport
+	Cortisol	Eicher, 2001	Increases during first 2 hrs	kalveren tot 3 mnd	transport upto 18 hr
+	cortisol + heart rate+ body temperature	Pettiford et al, 2008	Increase 1- 2 uur, thereafter lower	300 kg oxen	6 hr
+	Heart rate	Eicher, 2001	Increase during loading and unloading	Calves up to 3 mths	transport upto 18 hr
70-95	Heart rate	Genswein et al, 2007	Decrease during shorter transport	220 kg oxen	conditioned/ not conditioned, with 2.7 /15 hr transport
73-135	Heart rate	Schmeiduch, 2002	Bulls higher than heifers/oxen	heifers/bulls/oxen	Up to 29 hr

38.6-39.6	Body temperature	Schmeiduch, 2002	Highest at loading and after unloading, not critical	heifers/bulls/oxen	Up to 29 hr
+	Body weight	Schmeiduch, 2002	oxen ca. 6%, more bulls (restless)	heifers/bulls/oxen	Up to 29 hr
12-56	Cortisol	Schmeiduch, 2002	large difference in values for heifers and oxen/bulls	heifers/bulls/oxen	Up to 29 hr
3.2-4.6	Glucose	Schmeiduch, 2002	Differences between resting/ travelling regimes, higher by bulls than heifers.	heifers/bulls/oxen	Up to 29 hr
.7-.95	Magnesium	Schmeiduch, 2002	> 0.7 mmol/l: at end transport sometimes lower for heifers, oxen lower than bulls.	heifers/bulls/oxen	Up to 29 hr
1.5-3.0	T3 (trijodiumthyronin)	Schmeiduch, 2002	oxen lower and similar during transport, bulls higher no transport effect.	Bulls/oxen	Up to 29 hr
55-109	T4 (thyroxin)	Schmeiduch, 2002	Increases during transport, oxen lower	Bulls/oxen	Up to 29 hr
+/-	positive acute phase proteins, haptoglobulin,	Pineiro, 2007; Salamano, 2008		pig/ calves	
	salival IgA	Carins, 2002	increase?	Human	Increase also after fasting, resp. infections
	Insulin-like growth factor-I (IGF-I)	Davis, 2006	Decrease	Fish	
	IgG1	Mackenzie et al, 1997	Increase because of transportation	7 mths old suckling calves	0 / 2 hr
	IgA	Mackenzie et al, 1997	no transport effect, there is an effect from weaning	7 mths old suckling calves	0 / 2 hr
	IgM	Mackenzie et al, 1997	Unclear	7 mths old suckling calves	0 / 2 hr
	Concanavalin A-stimulated lymphocyte proliferation	Blecha, 1984	Decrease	calves 9 mths	10 hr
	high leucocyte and neutrophil combined with increased cortisol and catecholamines	Riodato et al, 2007		6 mths calves	14 hr transport
	Lymphocytes reduced	in Eicher, 2001			
	neutrophil% increased	in Eicher, 2001			
	Sensitive to infection	Stanger et all, 2005	reduction leucocytes	Oxen	72 hr transport
28.5-51.2	serum amyloid A	Arthington et al, 2003, 2008	Not clear	Beef calves	transport & mixing
+	Avoidence distance				
+	Abortions				
	pH (indication of DFD-meat)	Brown et al, 1990,			
5.53-6.00	pH (indication of DFD-meat)	Tarrant et al, 1992	higher after 24 hr transport		
	Sensitivity to gastro-intestinal worms	Genchi et al, 1986	higher epg's after transport	6 month calves	30 hr transport, without feed

Infection					
+/-	positive acute phase proteins	Pineiro, 2007; Salamano, 2008			
+/-	negative APP	Pineiro, 2007; Salamano, 2008			
+	Leucocyte count	Williams, 2008	Doubling	piglets 7 wks	16 hr transport (with or without pause of 8 hr)
+	natural killer cells	Williams, 2008	Doubling	piglets 7 wks	16 hr transport (with or without pause of 8 hr)
18-50	Cortisol	Buckham Sporer et al, 2007	High after loading, low after transport	Bull calves 6 mths	9 hr transport, once a week, 6 weeks
2-7	Neutrofiel	Buckham Sporer et al, 2007	higher during transport	Bull calves 6 mths	9 hr transport, once a week, 6 weeks
6000-17000	Testosterone	Buckham Sporer et al, 2008	High after loading	Bull calves 6 mths	9 hr transport, once a week, 6 weeks
4000-16000	Progesterone	Buckham Sporer et al, 2008	lower during transport	Bull calves 6 mths	9 hr transport, once a week, 6 weeks
9-13	Leucocytes	Buckham Sporer et al, 2008	Higher during transport	Bull calves 6 mths	9 hr transport, once a week, 6 weeks
	Excessive laying down after long journey	Knowles, 1998	Indication of fatigue (otherwise remain standing)	600kg bulls	after 16 hrs
34-278	creatine kinase	Tarrant, 1992	Higher with fatigue	cattle	15 – 24 hrs
	Young calves adjust more readily to transport				
Rejections					
	Young calves that die	Knowles, 1999			
	Glucose	Knowles, 1999	Increase		
	Free fatty acids	Knowles, 1999	Increase		
	Muscle enzymes	ormal , 1999	Increase		
	White blood cells	Knowles, 1999	Increase		
	Neutrophiles	Knowles, 1999	Increase		
	Lymphocytes, eosinefil and monocytes	Knowles, 1999	Decrease		
	blood pH	Schaefer et al, 1997	Decrease	Beef cattle	
	serum chloride,	Schaefer et al, 1997	Increase	Beef cattle	
	Haemoglobin	Schaefer et al, 1997	Increase	Beef cattle	
	urine Na	Schaefer et al, 1997	Increase	Beef cattle	

	Urine osmolarity	Schaefer et al, 1997	Increase	Beef cattle	
+	Somatic Cell Counts and cortisol	Yagi et al, 2003	Increase	Dairy cows	4 hrs
+	Leucocytes	Yagi et al, 2003			
39.8-43.0	Haematocriet	Fazio et all, 2005	No change	14 month cattle	30 hr transport, every 8 hours 1 hr rest, with feeding
1.28-3.58	Cortisol	Fazio et all, 2005	Higher	14 month cattle	30 uur transport, elke 8 uur 1 uur rust, wel voer
	Body weight	Fazio et all, 2005	6-12% lower	14 month cattle	30 uur transport, elke 8 uur 1 uur rust, wel voer
2.06-2.39	T3	Fazio et all, 2005	Increase	14 month cattle	30 uur transport, elke 8 uur 1 uur rust, wel voer
8.62-12.25	T4	Fazio et all, 2005	Increase	14 month cattle	30 uur transport, elke 8 uur 1 uur rust, wel voer
4.7-6.3	fT3	Fazio et all, 2005	Increase	14 month cattle	30 uur transport, elke 8 uur 1 uur rust, wel voer
1.56-2.00	fT4	Fazio et all, 2005	Increase	14 month cattle	30 uur transport, elke 8 uur 1 uur rust, wel voer
	Interferon (IFN-y),lymphocytes, body weight	Gupta, 2007	Decrease	HF-bulls, 400 kg	12 hr, different compartment sizes prior to
	neurophils, PCV, #RBC, heamaglobine	Gupta, 2007	Increase	HF-bulls, 400 kg	12 hr, different compartment sizes prior to
+	Insemination success	Yavas et al, 1996	No change	Beef heifers	1 hr before or after insemination
6000-9700	Leucocytes	Schmeiduch, 2002	Large individual and daily differences	Bulls/oxen	Up to 29 hrs
69/23-43/53	Lymphocytes/ Neutrofiel Extensively farmed animals	Schmeiduch, 2002, Cole et al, 1988 in Fisher et al, 2009	%lymphocytes reduced considerably during more stress	Bulls/oxen	Up to 29 hrs
0.028-0.16	Haptoglobin	Pettiford et al, 2008	increase (5-6 times higher)	300 kg oxen	6 hrs
	erythocytes, cortisol and lactate	Chacon et al, 2005	Increase	Slaughter bulls	0.5, 3 or 6 hrs

Appendix 2b. Parameters used to quantify risks to pigs during transit

Risks during transport Value	Method	Literature	Change in measurement value	Animal category	Duration transport
Fasting					
+	Gut fill				
+	Dunging frequency (number dung heaps in vehicle)				
+	Body weight		10%		
?	fat reserves	Moberg, 2000			
?	Growth				
+	Blood glucose	Krawczel, 2007	decrease	Lambs	22 hrs (with or without a pauze)
75-104	Blood glucose	Becerril-Herrera et al, 2010	Increase	gilts and boars	8 and 16 hrs
	blood urea	Krawczel, 2007	Increase	Lambs	22 hrs (with or without a pauze)
	Creatine	Krawczel, 2007	decrease	Lambs	22 hrs (with or without a pauze)
	Bilirubin	Krawczel, 2007	decrease	lambs	22 hrs (with or without a pauze)
	Leptin		decrease		
+	Protein catabolism (residual by-products, urea?)				
	serum pepsinogen A	Suchodolski, 2003	decrease	Dogs	
+	Groeihormoon	Moberg, 2000			
+	Steroid hormones (oestradiol, testosteron, LH)				
+	IGF-1	Moberg, 2000			
	Insulin-like growth factor binding proteins IGFBP)	Davis, 2006	Increase	Fish	
+	Heat production	Freetly, 2006	decrease	cattle	
No water					
+	Registration water use in vehicle				
+	Turgor				
+	Deeply set eyes				
+	Dry mucous membranes				
+	Colour mucous membranes				
+	consistency dung				
+	Body weight	Islam, 2004	decrease 12%	Rats	
+	Specific gravity urine/osmolality	Islam, 2004	Increase 110%	Rats	
	Urine volume	Islam, 2004	Decrease 87%	Rats	
	blood urea nitrogen	Islam, 2004	Increase 94%	Rats	
?	Vasopressin	Ramsay, 1991	Increase	Dogs	
?	Drinking water test				
+	Dung consistency (stress?)				
+	Ht/Hb				

Disturbance of normal behaviour					
+	daily time budgets, circadian pattern of rest and activity (e.g. time laying down)				
	Blood pressure	Ogawa, 2003	increase	human	after loss of sleep
+	vigilance (routine scanning of environment)	Moberg, 2000			
Thermoregulation					
+	Temperature registration in vehicle				
+	Shivering				
+	Panting				
+	Tongue hanging out				
Injuries					
+	Skin damages	Grandin, 1990		pigs	
+	Vulva injuries				
+	Shedding claws				
+	rectum prolapse				
+	Lameness				
	Pale soft exudative (PSE)	Lambooy, 2000, Scabga ea, 2003		pigs	
	Dark, firm dry (DFD)	Lambooy, 2000, Scanga ea, 2003		pigs	
	Meat colour			pigs	
	Water holding capacity			pigs	
Other sources of stress incl., new environment, loading/unloading, vibration vehicle, limited space, mixing with other animals, limited ventilation					
+	Deaths				
?	Heat production				
?	Reaction to secondary stressor				
+	Vocalizations	Weary,			
+	HRV	Von Borell, 2001			
+	Recovery HRV to base value				
+	Recovery heart beat to base value				
?	Motivation test (fear, exploration, locomotion)				
+	Cortisol	Gupta, 2007	Increase		
20-140	Cortisol	Perremans et al, 2001	Increase with vibration	Piglets	Differences in duration and frequency of vibrations
20-120	ACTH	Perremans et al, 2001	Increase with vibration	Piglets	Differences in duration and frequency of vibrations
+	Laying duration	Perremans et al, 2001	Shorter with higher frequecies	Piglets	Differences in duration and frequency of vibrations
30-70	Blood lactate	Becerril-Herrera et al, 2010	Increase	gilts and boars	8 and 16 hrs
29-44	haematocriet	Becerril-Herrera et al, 2010	Increase	gilts and boars	8 and 16 hrs
32-60	pCO2	Becerril-Herrera et al, 2010	decrease	gilts and boars	8 and 16 hrs
21-33	pO2	Becerril-Herrera et al, 2010	decrease	gilts and boars	8 and 16 hrs
140-149	Na	Becerril-Herrera	Increase	gilts and	8 and 16 hrs

		et al, 2010		boars	
1.24-1.60	Ca	Becerril-Herrera et al, 2010	Increase	gilts and boars	8 and 16 hrs
?	Albumin increase/-decrease				
+/-	positiev acute phase proteins	Pineiro, 2007; Salamano, 2008			
0.9-3.3	pig-MAP	Pineiro et al, 2007	Increase	100-125kg pigs	24-48 hrs
0.45-1.15	haptoglobin	Pineiro et al, 2007	Increase	100-125kg pigs	24-48 hrs
	Serum amyliod A	Pineiro er al, 2007	Increase	100-125kg pigs	24-48 hrs
15-20	C-reactive protein	Pineiro et al, 2007;	Increase	100-125kg pigs	24-48 hrs
+/-	negative APP (in pig ApoA-I, transthyrethrin)	Pineiro, 2007; Salamano, 2008			
+	faecal cortisol metabolites (FCM(conc))	Lepschy, 2010; Touca, 2005	Increase	rats	
	speeksel IgA	Carins, 2002	Increase?	human	Increase also after fasting, resp. infections
	Insulin-like growth factor-I (IGF-I)	Davis, 2006	Decrease	fish	
	concanavalin A-stimulated lymphocyte proliferation	Blecha, 1984	Decrease	calves 9 mths	10 hrs
	cortisol	Hambrecht et al, 2005	Increase during short transport	pigs	50 min- 3 hrs, normal, rough
	conductivity	Hambrecht et al, 2005	Increase during long transport	pigs	50 min- 3 uur, normal, rough
Infections					
+/-	positief acute phase proteins	Pineiro, 2007; Salamano, 2008			
0.9-3.3	pig-MAP	Pineiro et al, 2007	Increase	100-125kg pigs	24-48 hrs
0.45-1.15	Haptoglobin	Pineiro et al, 2007	Increase	100-125kg pigs	24-48 hrs
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+/-	Negative APP (ApoA-I, transthyrethrin)	Pineiro, 2007; Salamano, 2008			
+	Leucocyte count	Williams, 2008	Doubling	Piglets 7 wks	16 hrs transport (with or without 8 hr pauze)
+	natural killer cells	Williams, 2008	Doubling	Piglets 7 wks	16 hrs transport (with or without 8 hr pauze)

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