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COMMISSION OF THE EUROPEAN COMMUNITIES

COM(85) 70 final

Brussels, 5 March 1985

COMMUNICATION FROM THE COMMISSION TO THE COUNCIL

concerning the protection of animals during international transport

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COM(85) 70 final

EXPLANATORY NOTE

On the 12 May 1981 the Council adopted Directive 81/389/EEC[(1)] establishing certain measures necessary for the application of Directive 77/489/EEC concerning the protection of animals in international transport.

The Commission agreed to ask the Standing Committee for Agricultural Research (SCAR) to exmaine whether there are good physiological, ethological and economic reasons for limiting the final journey to the abattoir of animals for immediate slaughter and, if so, of recommending a maximum duration for such journeys.

The SCAR studied this question on the basis of an extensive examination of the problems by a group of experts representative of the Member States.

The conclusions and considerations reached by SCAR, and the expert report entitles "International Transport of Farm Animals intended for slaughter" are annexed to the present communication.

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COMMUNICATION FROM THE COMMISSION TO THE COUNCIL

concerning the protection of animals during international transport

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1. Introduction

On the 12th May 1981 the Council adopted Directive 81/389/EEC (1) establishing certain measures necessary for the application of Directive 77/489/EEC concerning the protection of animals in international transport.

The Commission agreed to ask the Standing Committee for Agricultural Research (SCAR) to examine whether there are good physiological, ethological and economic reasons for limiting the final journey to the abbatoir of animals for immediate slaughter and, if so, of recommending a maximum duration for such journeys.

The SCAR studied this question on the basis of an extensive examination of the problems by a group of experts representative of the Member States.

The conclusions and considerations reached by SCAR, and the expert report entitled "International Transport of Farm Animals intended for slaughter" are annexed to the present communication.

2. Report of the Standing Committee for Agricultural Research

Following a consideration of the expert report the Standing Committee for Agricultural research agreed that:-

"It will therefore be seen that both the content of individual chapters and the conclusions which can be drawn from the available data show more information is required before a specific answer can be given to the original question:

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(1) O.J. L.150 of 06.06.1981, p. 1

"Are there good, physiological, ethological, and economic reasons for limiting the final journey to the abattoir for animals intended for immediate slaughter and, if so, of recommending a maximum duration for such journeys."

Specifically, further research would seem to be needed into the following areas:

(1) Feed and Watering

When and how should animals be fed and watered prior to and during transport, according to their age, species and physiological condition?

(2) Resting

What is the importance to the animal of rest during transport? By what means can animals be provided with appropriate environments during transport in which they may rest? Is there a need alternatively for journeys to be broken - and at what intervals - and animals unloaded for resting?

(3) Stocking Rates

What are suitable stocking densities and group size by species, age, sex and physiological conditions?

(4) Ventilation

What are the ventilation requirements of the different modes of transport for the different species and class of livestock?

(5) Physiology

Continued investigation of the various physiological factors may help in the assessment of changes in stress and behaviour of livestock during transit. What is the significance of these observations in relation to the animal's need for food, or water, or rest?

The monitoring of livestock being transported involving the collection of data on morbidity, mortality and injury during transport and the effect of transport conditions on meat quantity and quality are topics of crucial importance. The work requires the closest possible co-operation between Member States of the Community. This can and should be assisted through Commission initiatives in:

(1) the planning, co-ordination and discussion of laboratory and field investigations using the expertise and facilities which exist within Member States;

(2) the further encouragement of the exchange of information, by way of seminars and work-shops;

(3) the continuing exchange of research workers and others having practical training or administrative experience to offer.

There are indications of the priorities to be worked on if the paucity of information, in certain aspects, is to be solved; clearly more work will give more results but not necessarily all the answers."

3. The Commission has considered this report. In view of the conclusions and recommendations made it considers that it would be premature at the present time to make proposals to the Council for amendments to the existing Community Directives which have been adopted in this sector.

4. It is apparent that if a better scientific basis is to be found to enable progress on these questions it will be necessary for further financial resources to be made available for specific areas of research, and to support projects of co-operation between Member States to monitor livestock being transported so that essential data can be collected.

5. At the same time the attention of the Commission has been drawn to the necessity of taking more immediate practical steps to facilitate the application of the existing Community provisions as regards the International transport of animals. The parliament in its resolution No. 229/83 in particular requested further improvements in respect of the International transport of horses intended for slaughter.

These problems are also subject to consideration under the auspices of the Council of Europe where particular questions of transport from non-member countries are of importance.

6. In view of this situation the Commission considers that a useful role could be played in the immediate future by the development of European Codes of practice for the international transport of animals. There is a need, even within the limitations of existing data and knowledge, to improve the dissemination of knowledge at the level of education and in particular for the many citizens who in their daily lives are concerned with the international transport of animals.

   The development of these codes by the Commission would involve considerable work and close co-operation with the authorities of Member States and consultation of the interested parties within the Community.

7. Neither further research nor development of practical advisory codes are at present possible due to the absence of the necessary financial and staff resources. The Commission has already indicated to the Council this problem which is general to the sectors of work involving the protection of farm animals.

International transport of farm animals intended for slaughter

An examination of whether there are good physiological, ethological and economic reasons for limiting the final journey to the abattoir of animals intended for immediate slaughter and, if so, of recommending a maximum duration for such journeys.

September 1984

VI/4746/84-EN.

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1. Introduction

1.1. Reasons for the report

The aim of this examination was to attempt to answer the question posed to the Commission of the European Communities (CEC) Standing Committee for Agricultural Research (SCAR) by the Council of the European Communities. The question asked in 1980 was:

Are there good physiological, ethological, and economic reasons for limiting the final journey to the abattoir of animals intended for immediate slaughter and, if so, of recommending a maximum duration for such journeys?

Within the European Communities thousands of slaughter animals are transported from one country to another every day. Distances range from a few kilometres to hundreds and thousands of kilometres. The duration of such journeys runs from a few hours to some days. For some years there have been complaints because animals transported internationally were found in a poor condition in transit or at their destination.

In attempting to answer the main question, based on an examination of the current scientific literature, and valued experience in practice and to cover such complaints, four main considerations were identified:

1. Are certain types of transport better than others? For example, road versus rail versus boat.
2. What are the effects of loading, reloading and unloading on the welfare of transported animals?
3. What are the economic aspects of transportation?
4. Is research needed to answer questions on international transport of farm animals?

1.2. Background and keyfactors

Concern has focussed on transportation and its effects, not only because of the need to assess stock requirements and normal comfort during travel, but because of bruising, or even death, occurring before arrival at the destination (Pearson and Kilgour, 1980). Hails (1978) in his study pointed out some key factors:

(1) The great increase in numbers of animals now being transported

(2) The complicated nature of the variables operating during transportation

(3) Weather, loading density and distance travelled are factors in stress

(4) Prior husbandry experience is a very important factor.

(5) Many vehicles used for stock transport are poorly designed

(6) The concern for the animal being transported is in direct proportion to its value

(7) Some diseases are associated with transportation.

According to Pearson and Kilgour (1980) the transport of animals involves a great variety of factors with which animals have to cope. If each factor is taken separately it would pose few problems for the transported animal, but in combination they may lead to changes of behaviour and metabolism or cause pathological conditions. Among the factors to be considered are climatic conditions, handling, food and water intake, exercise, social interactions, transport types, environment change and duration of journey.

In 1971 "The European Convention for the Protection of Animals during International Transport" was promulgated by the Council of Europe. The aim of the Convention is to establish common minimum provisions for the protection of animals ensuring their welfare. The most important regulations relevant to the transport of farm animals were discussed by ADLER (1982), namely, that in the country of export the animals should be inspected by a veterinary officer who is responsible for

(1) the animals being deemed fit for transport
(2) satisfactory loading arrangements
(3) a certificate stating identity, that the animals are fit to travel and a record of the means of transportation.

Veterinary officers in all countries through which animals are transported are entitled to prescribe rest and care for the animals where considered necessary.
The Convention lays down the following points:

1. Adequate space and room to lie down should be provided.
2. Vehicle construction shall ensure protection against inclement weather conditions and proper ventilation.
3. Boxes and cages should be labelled and easy to clean; they must ensure safety of the animals and allow inspection.
4. Floors must be solid, close boarded and prevent slipping.
5. There shall be segregation according to species, age (young and adult should be separated), sex (uncastrated adults should be kept separate from female adults boars and stallions separate from each other).
6. Bovines shall not be tied by the horns. Ties should be of adequate strength and allow for lying down, eating and drinking. Bulls above 18 months of age shall be tied and fitted with nose rings for handling only.

7. Solipeds shall wear halters and shall have individual stalls or their hind feet unshoed.
8. Suitable equipment shall be used to prevent slipping and falling down.
9. Consigments of livestock shall be accompanied by an attendant (unless carried in containers or other measures taken).
10. Animals becoming ill or injured shall have veterinary attendance as soon as possible and if necessary shall be slaughtered without unnecessary suffering.
11. Ill or injured animals shall be considered not fit for transportation. Those becoming ill or injured are to be given first aid and submitted to veterinary examination.
12. When animals placed above each other in containers or on floors the falling of droppings on animals underneath shall be avoided.

The 10 Member States of the European Communities and 8 non-member countries (Austria, Cyprus, Finland, Norway, Spain, Sweden, Switzerland and Turkey) signed the Convention. Since 1979 the European Communities as a group has had the status of a contracting party. EEC Directives 77/489 and 81/389 embody the Convention.

In international transport of farm animals special problems appear because the animals are often imported or in transit from countries, which have not signed the Convention.
For example, especially difficult situations arise on the German border with transport from Poland and the Soviet Union, because refusals on this border are not practicable, and because East Germany does not take back such transports.

The necessary regulation certificates concerning the law relating to contagious diseases from these countries verify the health and absence of epidemics but they do not give information on the fitness to travel of the animals, the time of loading and the rest periods that have to be kept (Geyer, 1982). One of the main problems is, who is responsible for the animals during international transport. The animals are loaded in foreign countries, and they are not accompanied by the owner, but by hired people. This results in the consequence that in the case of complaints direct influences on the owner are nearly impossible.

1.2.1. Stress factors

The stress concept and its relation to transport is central to the understanding of the reactions of livestock during transportation.
Selye (1950) considered stress to be a response of the organism to some experimental treatment or environmental feature that induces deviation from homeostasis. The environmental factors which lead to stress are referred to as stressors.

Adaptation involves both metabolic adjustments and behavioural (coping) responses. Stress occurs when normal adaptive mechanisms are inefficient to control certain situations. Stress is the process by which environmental factors over-tax these control systems in an individual, thus activating responses whose effects are prolonged and ultimately detrimental to that individual in that they reduce its fitness (Broom, 1983).

Stress can be assessed by direct or indirect signs of the activation of the main hormonal systems involved in adaptation, the pituitary-adrenal system which releases corticosteroids and the sympathetic-adrenal medullary system which release catecholamines (adrenaline and noradrenaline). In addition various behavioural responses which alter the state of an individual or signal the failure of the individual to cope with the situation are recognisable stress responses.

Because of the dynamics of the stress response and the multiplicity of its components, there is no single measure of the degrees of stress which must therefore be assessed by the simultaneous measurement of several "indicators" (Stephens, 1980; Dantzer et al., 1983).

Transport to slaughter is likely to involve several factors which may be stressors (Porzig 1969, Dantzer and Mormède 1979 pp 12-21, van Logtestijn and Romme 1981). These include:

1. Physical factors such as noise, vibration and forceful contact with the vehicle or other animals. These can be exacerbated by, for example, close confinement, poor vehicle design, and excessive movement of vehicle. They may result in injuries which further stress the animal.

2. Environmental factors such as temperature, humidity, oxygen level or the presence of noxious gases. These factors may be of minor importance at the start of a journey but may become important as the journey progresses. High temperature often associated with high humidity, is a frequent stressor.

3. Metabolic factors such as those resulting from insufficient consumption of water or food. These may be present even when water and food have been available but not consumed.

4. Factors resulting from lack of exercise or prolonged standing.

5. Factors resulting from novelty or from treatment by handlers or other animals. The loading procedures, the transporter and the other animals being transported will often be strange and frightening to the animal. The human handlers may not treat the animals in a manner which minimises stress and individual animals, forced into close proximity to others who may be unfamiliar, are often under stress and may fight.

Fighting can lead to injuries and further stress.

These factors may have a greater effect in concert than when acting individually. For example an environmental temperature which is not sufficiently high to have any adverse effect may be a stressor if it occurs at the same time as forced association with strangers. Such interactions and indeed the relative importance of the various factors, are poorly understood. The most dramatic effect of transport is the death of an animal before or very soon after reaching the destination. This is an important problem in pigs and has been the subject of much research (for example Van Logtestijn et al. 1982), because pigs are more susceptible to transport stress than other species of farm animals (Sybesma 1968; Lendfers, 1970, 1975). Tarrant (1982) described the porcine stress syndrome as the acute reaction to stress, mediated by the sympathetic nervous system, which can cause severe distress and even death. In relation to this, it has to be noted that affected animals show severe signs of dyspnoea, cyanosis and hyperthermia, and they may develop rigor in the limbs before death occurs. This links up with the findings of Clark (1979), who found in 70% of the transport related deaths diffuse and severe pulmonary congestion, often accompanied by a moderate degree of pulmonary oedema. The hearts of these pigs were contracted and pale. Thirteen per cent of the other dead animals showed a variety of lesions from acute to chronic, in addition to the pulmonary congestion and oedema, while only 1.9% had no lesions at all. Circulatory collapse also occurs in broilers. Löliger and Torges (1977) observed a death rate of 0.08% after transport of 56,000 birds. A percentage of 0.07% died because of circulatory collapse, while the others died from injuries (0.004%) and non-transport-related diseases or infections (0.004%). This is comparable to hens with a death rate of 1.46% in which also most of the casualties died because of acute circulatory heart collapse and 0.17% of injuries or diseases (0.13%) of different organs which occurred before transportation.

Bergmann, (1978, 1979) studied changes in cardiac and skeletal muscles of pigs following transport stress and found clinical signs of exhaustion and acute circulatory insufficiency. All these symptoms are attributable to the excessive muscle metabolism which leads to acidosis and hypercapnia. The concentrations of lactate and carbon dioxide in the circulation stimulate the release of catecholamines and anaerobiosis even further. Therefore, one of the suggestions is that the pigs are thought to die in a state of cardiogenic shock, but there is no physiological evidence which verifies this assumption. Another suggestion, much more important than the environmental influences, is the stress susceptibility of the pigs. Many cases of transport losses in pigs, which range between 70 and 80% during transportation, while the remainder occur in the abattoir, can be attributed to the malignant hyperthermia syndrome (MHS). This syndrome, which is an indication for stress-susceptibility, is genetically determined, probably by an autosomal recessive gene. Pigs suffering from the MHS, can be identified at an age of 6-12 weeks by means of the halothane-test. As a result of this test the percentage of reactors in the Dutch Landrace breed could be dramatically reduced (Sybesma and Eikelenboom 1969-1979).

Stress, whatever its cause has economically important effects on meat quality as well as being bad for the welfare of the animals. The dark cutting or DFD (dark, firm, dry) condition is a direct consequence of stress and exhaustion during the preslaughter period (Tarrant, 1981) and has been observed to occur in many meat species. The physiology of DFD depends on muscle glycogen breakdown that is stimulated by circulating adrenaline and by the contractile activity of muscle during preslaughter transport and handling, e.g. during social regrouping in young bulls (Tarrant, 1982, McVeigh and Tarrant, 1983).

The PSE (pale, soft, exudative) condition, on the other hand, has a genetic base and is associated with hereditary susceptibility to stress in pigs (MHS). Environmental stressors may increase the incidence or severity of the PSE-condition, its elimination partly on selection of stress-resistant slaughter stock.
Injuries, including bruising, may also occur during transport and, besides reducing carcass and meat quality, may be at the source of intense suffering. The incidence of death, injuries, reduced meat quality, susceptibility to disease and physiological and behavioural signs of stress is much higher during or after transports than during any other comparable period of the life of farm animals.

Although it is apparent that transportation is a critical period for the animal, adverse economic and welfare effects can be alleviated by good conditions and careful handling.

1.2.2. Feeding and Watering

"The European Convention for the Protection of Animals during International Transport" advises that food and water shall be given at suitable intervals. Animals shall not be left more than 24 hours without being fed and watered. This period may, however, be extended if the journey to the destination where the animals are unloaded can be completed within a reasonable time. The animals shall be fed and watered by the attendant of the transport, and cows are to be milked at intervals of not more than 12 hours.

There are doubts that these times suit all animals. These figures are not based on scientific research and maybe young animals or monogastric animals need to be fed and watered more often. Feeding and watering during transportation are important and are discussed in further detail later in the report (p 12). There is national legislation which covers internal transport in each Member State.

According to the report of the Agricultural Departments (1978) experts in animal husbandry and nutrition are of the opinion that even calves which are still on a liquid diet may go for 24 hours between feeds without ill effect. While even longer periods would not necessarily harm the animal, an interval as long as 36 hours could cause a setback to the calf's development. If the length of journey were such that feeding became necessary on the way, the calves should be unloaded and rested for 2 or 3 hrs before being fed, and should then only be given a maintenance level of feed.
These experts advise further that for ruminating cattle and sheep water is more important than food on a journey. While ruminating animals could travel for 36 hrs or possible more between feeds without suffering any ill effect, they should not go for intervals longer than 24 hrs without being watered. Under good environmental conditions a period of more than 24 hrs without water would not necessarily be detrimental but 36 hrs would probably be excessive.

According to the Convention adequate food and water shall be available for poultry unless the journey is less than 12 hrs or a journey lasting less than 24 hrs for day-old chicks providing the journey is completed within 24 hrs of hatching.

Despite both national and international legislation on feeding and watering which requires livestock to be fed and watered at specific stated intervals there are doubts that such time intervals suit all species and ages.

1.2.3. Grouping

This is a key factor but very little work has been carried out as yet. The 1971 Convention of the Council of Europe laid down, if animals of various species travel in the same truck, vehicle, vessel or aircraft, they shall be segregrated according to species. Furthermore special measures shall be taken to avoid adverse reactions which might result from the transport in the same consignment of species naturally hostile to each other. When animals of different ages are carried in the same truck, vehicle, vessel, or aircraft, adult and young animals shall be kept separate; this restriction shall not, however, apply to females travelling with their young which they suckle. With regard to bovine, and porcine animals, mature uncastrated males shall also be separated from each other; this shall also apply to stallions.
The Convention, however, does not make any remarks on group size or loading density.

Although in national and international legislation loading densities are quoted for various species, weights and ages of animals, group size is not mentioned despite its obvious importance.

2. General criteria

2.1. On-farm preparation

According to Wythes et al. (1980) good welfare on the farm primary to transport is a matter of good handling, yard design and construction. The Ammerdown Group (1980) however, comes to the conclusion that this welfare leaves much to be desired, due to over-vigorous treatment, the use of sticks, electric prodders and dogs.

2.1.1. Feeding and watering

The questions whether to feed and water animals before long journeys, the quantities of food and water and the best time for the last meal before loading, have not been yet satisfactorily answered.

Cattle

Dodt et al. (1979) found, that bullocks fasted in yards for 24 and 48 hours were more bruised than those not fasted. They attributed the difference to agonistic behaviour in order to establish the new social rank. Wythes et al. (1980) found horns account for approximately half of all bruising in cattle. Thus dehorning would improve animal welfare during marketing and grouping before transport. The German Gutachten (1977) advises not to feed and water cattle before loading above a weight of the rumen of about 10 to 15% of the animal's live weight. Only watering cattle does not induce any problem. Stephens (1982) could not detect any effect on "digestive scours" in calves, that were either overfed or not fed at all and transported for two hours after the last meal of milk replacer.

Pigs

Food can have a detrimental influence on the well-being of pigs. Schütz (1975) found a highly significant increase in heart rate in correlation with a shorter lapse of time between feeding and transportation. A fasting period of 24 hrs before transport appeared to have the lowest negative influence on the cardio-vascular system during transport. A longer fasting period than 24 hrs caused considerable weight losses. The Meat & Livestock Commission (1974) recommends that pigs should be watered but not be fed on the day of collection to be slaughtered. Wythes et al. (1980) report a Queensland survey, showing smaller transport losses in pigs during transport if

they had been given no food in excess of 12 hrs before loading, compared with those that had been fed until transport. Warris (1982) compared the effects of different fasting times before transport. In order to prevent economically important losses the author advises that the time between the last meal and actual killing should not exceed 18 hrs. Markov (1981) reports weight losses in pigs on transport up to 10,2%, caused by journeys of 2,5 to 3 days.
There obviously is a common opinion that pigs should not be fed at the day of collection for transport. Everybody agrees that pigs should have water available until the actual loading starts.

Sheep

Hinrichsen (1979) and Grandin (1981) recommend that sheep should be watered and fed sufficiently but not excessively before transportation. If the transport will not last longer than 8 hrs Grandin prefers a fasting period (for food and water) of 16 hrs prior to loading. Hinrichsen demands feeding of 1 day old lambs destined for fattening, in intervals no longer than 8 hrs during transport.

There is general agreement that on the day of transportation pigs should be allowed water ad libitum but not other feeds. From the existing regulations on watering, feeding and recting prior to export for species other than pigs and the recommendations for fasting periods prior to transport it is clear that more research is required to establish definitive guidelines.

2.1.2. Grouping

Unfamiliar environments are one of the most stressfull aspects of transport and preslaughter handling procedures. Platt (1982) recommends a period of conditioning at assembly lairages. For bulk transport of free ranging animals this period of adjustment is particularly relevant. The lairages should be located near the embarkation points. In this period stock become used to the diet, that will be fed on the voyage itself. The animals also become more manageable and loading is less stressfull.

Cattle

Strange farm animals penned together will start a fight in order to establish a rankorder. Kenny & Tarrant (1981) showed that mixed penning of steers before slaughter increased the incidence of mild and moderately bruised carcasses, but not the number of severe ones. Apart from dehorning unnecessary mixing of strange groups of animals will reduce the incidence of bruised carcasses. Thus pens for lairage should not be too large, in order to be able to keep groups separated.

Pigs

After a fattening period of about 4 months, without having encountered strange pigs, slaughter pigs were suddenly removed (Van Putten and Lambooy 1982) from their usual pen and mixed with pigs they had never met before. There was much resultant confusion and fighting. The mixing of pigs for transport causes stressors to accumulate, for example (1) leaving a familiar environment (2) losing the contact of penmates (3) encountering antagonism with strange pigs.

Van Putten and Lambooy (1982) showed for air transport that, by grouping and mixing a few days in advance, strange pigs destined to travel in one compartment of a container then handling was easier and less stressful. Furthermore such a practice avoided the use of tranquillizers such as Azaperone and the after effects. Schmidt and Van Lengerken (1980) and Schlicht (1980) advised strongly in order to prevent losses not to mix pigs from different pens.

Experience gained from air transport Moss (1978), Schmidt and Van Lengerken (1980) Schlicht (1980) and by many others should be considered for application to other forms of international transport.

The Meat and Livestock Commission (1974) strongly advises that pigs from different fattening pens should be kept separately before loading in order to reduce stress and the likelihood of fighting.

Sheep

The Ammerdown Group (1980) advised that sheep should be handled with great care. Extensive haemorrhages may be caused by lifting by the fleece. Such handling is likely to create both stress and physical damage and this often becomes apparent only after the animal has been slaughtered. To prevent rough handling, the group recommended adequately sized, strongly built holding pens, a ramp to load the animals at the tailboard level of lorries and wherever possible the avoidance of stick, electric goads, dogs and noise.

Prearranged grouping of animals well before the actual transport starts decreases social stress considerably during transport and thereby prevents accumulation of stressing factors.

2.1.3. Assembly points, markets and lairages

On the continent animals are picked up at the farms of origin and are transported directly to the slaughter-house or the assembly point for export. In Great Britain and Ireland animals often pass through a market, assembly point or lairage before starting their final journey. The Ammerdown Group (1980) reports that 50% of all cattle and 70% of all sheep pass through market before being transported to the slaughter-house. Pigs are only exceptionally sold via auctions.

Cattle

According to the Ammerdown Group (1980) cattle generally are loaded, unloaded or reloaded no less than four times. Even with adequate facilities this procedure causes much stress and physical damage and reduces carcass quality. Apart from this the bruises and stressfull situations are detrimental for the animal's welfare. These cattle suffer from noise, from mixing with unfamiliar animals again and again, attacks from animals in adjourning pens, restlessness by continous moving of other animals and blows and noise whilst being driven from one place to another.

According to Dow (1976) the purpose of lairage is to reduce the level of stress induced by previous handling. In Great Britain before export animals must be rested for at least 10 hrs in a Government approved lairage at or near the port or airport of departure (Agricultural Department, 1978). The following requirements have to be satisfied:

(1) The animals in lairage must be provided with an adequate supply of suitable food and water,

(2) All animals must be examined at the lairage by an official veterinary officer. He issues a certificate valid for 18 hrs from the time of examination.

(3) Lairage operators must keep proper records of the animals' movements.
(4) Calves must weigh at least 50 kg, and any underweight calves are turned back.

Detailed requirements for lairages include the provision of:
(1) sufficient clean bedding;
(2) separate pens for different species arranged so that not more than 40 cattle, 40 pigs or 100 sheep are detained in one pen or enclosure;
(3) experienced and competent supervision
(4) isolation pens
(5) regular cleaning and desinfection.

Not withstanding some general ideas about how to keep animals at lairage, in order to let them rest, far too little information is available to establish definitive guidelines.
In terms of pre-transport preparation, from regulations requiring watering, feeding and resting prior to export (Agriculture Departments 1978) to varying recommendations as to fasting periods prior to transport (Stephens (1982), Warris (1982), Grandin (1981), lead to the conclusion that much more research is required before definitive guidelines can be given.

2.2. Transport

International transport may last from a few hours to some weeks. Most experiences and research are based on relatively short duration transportation within one country. It would not be correct to extrapolate these data to international transport lasting some days. Besides, during transportation over long distances extreme climatic differences may be encountered and long periods of waiting for clearing by customs at the borders can occur.

2.2.1. Loading and the actual journey

One of the most stressful parts related to transportation is loading. This applies especially to moving the animals from their home-pen into the transporting vehicle.

Horses

Loading of horses is difficult if the loading bridge is not quite stable, if the outside and inside light-conditions are different and if the hoofs on the loading-bridge sound hollow (Frohner, 1961). Therefore Hinrichsen & Körner (1978) advise to keep the noises as low as possible during loading and to cover the loading-bridge with straw or with coconut matting.

Cattle

Cattle trucks should load from the end rather than from the side. Side-loading trucks may confront cattle with the decision to turn once they are inside (Anderson, 1973), and then end up turning around completely therefore facing the door (Sutton et al., 1967) and making it very difficult for other animals to enter. According to Grandin (1980b) cattle move more easily if they can see an animal ahead, if the driveway is curved instead of straight, and surrounded by solid fences. Cattle enter facilities more easily, if they are well lit.
Well designed ramps encourage cattle to move and climb. Handlers should keep in mind that cattle move slowly and should not be forced by electric prods and rough treatment to move fast. Such routines, acknowledging cattle behaviour, would help to minimize transport stress.
In another study Grandin (1979) reports that leg and foot injuries can occur if the truck is not properly positioned against the loading dock, and recommends that the loading chute should be equipped with telescoping side pannels and a selfaligning dock bumper to prevent animals from jumping out through the gap between the back of the truck and the chute.

Many animals are injured because the loading chute is too steep.
The slope of a permanently installed loading chute for cattle or hogs should not exceed 20°. The slope of portable or adjustable chutes should not exceed 25°. Stairsteps ramps are best for cattle and pigs. Prolonged travelling is not necessarily detrimental to the welfare of cattle. Friend et al. (1981) transported 150 Angus x Hereford calves, weighing on average 164 kg for 70 hrs by rail and 36 hrs by truck. Despite this travelling during five days, no negative effects or stress could be detected. Gastmann (1977) reports that during the first 30 hrs of transport (German Democratic Rep.) no tissue losses occur. Afterwards the weight-losses of the carcass are about 0,12% per hr. Losses were higher in young animals and lower in older ones.

Pigs

According to Van Putten & Lambooy (1982) in most pig farms handling and loading facilities are very poor, and designers never seem to have cared about it, despite the results of many experiments, indicating that these conditions do matter. Schlicht (1980) stresses this point and so does Grätz (1981). Van Putten & Elshof (1978 analysed the stressing factors in handling and loading slaughter pigs by means of radio telemetric recording of the heart rate of 50 pigs. The loading bridge caused the largest stress. The electric probe-stick had an increasingly bad effect every time it was used. Entering an unknown dark room was much more stressful than entering a relatively light unknown room and took three times as long. The slope of the loading bridge had a direct correlation with the heart rate of the pigs. The C.B.I. (1977) gives the following advice concerning the treatment of slaughter pigs at the farm:

(1) tagging should not be done in the fattening pen but on the lifting platform or in a special pen at the base of the loading ramp;
(2) special light switches should be installed to always enable pigs to walk from a relatively dark place to a bright one;
(3) no obstacles should hinder pigs whilst they are being driven through the passages, for example narrow places (doors), unstable parts of the floor (ventilation grids) steps or sharp turns;
(4) slaughter pigs should remain inside on their way to the lorry, because they hate rain and wind and have never had any similar experience;
(5) every fattening pen should have a door, leading to a broad passage way
(6) no trough should be in their way;
(7) only small groups (about ten pigs) should be driven at a time, by a man with a board behind them.

The Scientific Commission on Intensive Livestock (1978) reports that at several farms in Holland farmers have begun to build small collecting sheds placed against the outer wall of the pig shed, equipped with a ramp to make it easier for the animals to be loaded into trucks. On the evening before transportation, the pigs are driven into these small collecting pens by the stockman. Only pen-mates are placed together to prevent fighting. Upon being loaded the pigs will leave these unfamiliar surroundings more readily than if they were loaded directly from their habitual stalls or pens. There is evidence that mortality is lower during transport when the animals are collected into the special preloading pens a few hours before transport. Also under the conditions of industrial pig production in Eastern Germany Schlicht (1980) recommends driving slaughter pigs 1 to 2 hr prior to transportation carefully to the ramp in order to avoid uneasiness and excitement. They are kept there till loading, and due to this procedure pigs get

used to the changed environmental conditions (temperature, light, floor) and to walking.
Drawer (1971) summarizes cruel methods often used in practice in driving animals into the transport vehicle. An example is forcing animals to move faster than they normally walk. Pigs especially move much slower than human beings. The excessive use of electric goads, often applied to handicaped or injured animals to the last animals of a crowd wedged in is very cruel. Pulling or throwing pigs down off lorries without using a ramp is cruel.
Since pigs often balk at bright sunlight, if they have to leave the stable in the course of loading, Grandin (1982b) recommends covered loading chutes. If a stationary ramp is not available the loading bridge can be covered with canvas or plywood. These closed ramps and the lorry should be equipped with artificial lighting. Schlicht (1980) also recommends roofing ramps to protect animals from inclement weather conditions which may cause them to refuse to enter the ramp; and advises that the animals be allowed to walk across an even bridge into the lorry in order not to stress them by forcing them to climb a steep loading bridge.

According to Smith & Allen (1976) transport losses are relatively low below 10°C but increase rapidly above 18°C. The authors developed a hyperbolic curve from which the mortality at any temperature can be predicted. Allen et al. (1974) as well as Sybesma et al. (1978) report seasonal changes in deathrate of pigs on transport, revealing the summer months are much higher than the winter months. According to Sybesma et al. (1978) seasonal fluctuations of 0.53% in August and 0.27% in December are possible although they found that these differences are less important than the striking differences between the average deathrate of different slaughter-houses; 0.72% and 0.22%.

There are indications that pigs are in a better condition after travelling long distances compared to short distances but information is limited. In a study by Augustini (1976) pigs were transported either for 300 km or 30 km. He found that the pigs were in a better shape after the longer lasting transportations. With increasing transport distance heart frequency and body temperature decreased. He also stated that the biggest negative influence arose from weather conditions (high temperature and a high relative humidity). The next important negative influence was the loading-density and transport distance was third in the priorities of negative influences. Whether this can also be applied to very long distances, is not known.
Climatic conditions during transport are a major concern of many authors, especially since pigs are very sensitive to hot temperatures. Van Putten & Lambooy (1982) give the example that crossing the Alps may mean a frost of -10°C, whereas next day in Italy the temperature may rise to 20°C and more. The authors are concerned about regulations for large ventilation openings being too strict. Driving style also influences deathrate during transport.The Meat and Livestock Commission (1974) recommends driving at even speeds with a minimum of severe braking. As far as possible loaded vehicles should keep on the move. If vehicles are stationary for any lenght of time, including stationary rest periods, air flow is greatly reduced, heat builds up, and the likelihood of losses increases. Scharner et al. (1979) performed electrocardiographic investigations on pigs for slaughter transported by a lorry across 10 and 40 km. Heart frequency depended on the kind of road the driver took. Driving on the even and bendless Autobahn led to a decrease and a certain constancy of heart frequency. Driving on normal roads and adaptation to that kind of traffic, with all the stopping and speeding up increased heartrate. According to the Scientific Commission (1978) there are big differences between truck drivers and enquiries have shown that some truck drivers have a worse

record of dead pigs during transport than their colleagues. It is recommended that truck drivers who understand the behaviour of pigs are better able to handle these animals with calmness and firmness, and are preferred for this type of work.
The use of tranquillizers on pigs may assist by reducing stress, fighting and weight loss in transit. However current legislation in most countries limits their use. Therefore tranquillizers should not be administered less than 24 hr before slaughter, which is of very little value in practice. Allen et al. (1974) mention that the use of Azaperone in Belgium significantly reduced the number of transport deaths and lowered the incidence of inferior meat quality. Verstraaten & Dietmann (1979) have tested the blocker Carazolol as an alternative. They found that unlike sedativa this B-blocker did not cause drownsiness. The numbers of transport losses and of animals with a poor meat quality (PSE) were significantly higher in the group of animals not treated.

Sheep

Sheep should be loaded as quietly as possible, avoiding the use of sticks and other forms of force. Most of the damage occurring during haulage takes place at loading and unloading. Attempts to hurry stock usually have the opposite effect, causing stock to slip and fall. Partitions or rear loading gates should not be used to force sheep into the vehicle (Meat & Livestock Commission, 1974). Probably the longest journeys are in transporting sheep. Since Australia is one of the main countries exporting sheep then long distances have to be covered to reach the destinations. Export of living sheep for instance from Australia or from New Zealand may take place by road, by rail and then by sea through a tropical conditions. This transportation might take as long as 30 days (Pearson & Kilgour, 1980). According to these authors some experiences show that even such long transportation times can be sustained

by the animals provided adequate care is given and if possible some pre-training is undertaken before the final journey.
Drivers of international transporters should select transit routes very carefully to avoid problems. Transport by road cah be unexpectedly extended if the driver does not find the right way and gets lost. This has happened with drivers from East European countries in Germany and caused in one case a high deathrate in sheep (Pevec, 1982).

Poultry

Gerrits & De Koning (1982) describe loading of broilers. By the most used loading method in The Netherlands 16 crates are placed on pallets and are transported between the lorry and boilerhouse using a tractor forklift. In the broilerhouse four catchers fill the crates, while two other persons handle the empty crates and the full ones. The full crates are stacked by two people on the lorry, while a third man placed 16 empty crates on an empty pallet. The catching of broilers in a broiler-house is usually done by picking up a bunch of four or five animals by the legs and squeezing them into the crate. Another method of catching, which is not applied as frequently, but nevertheless merits attention, involves catchers crawling around on the floor and picking up two animals by the sides with both hands. In this method the wing remains closed; the risk of injuries to leg- or hipjoints is reduced. If broilerhouses do have doors in the side-wall another method is practicable. Two people pick up the animals in bunches of five and hand them over to the "carriers", who walk to the lorry with a bunch in each hand. The lorry is parked at the door and the two or three people there, stack the crates on the loading floor of the lorry.

Obviously loading and unloading facilities group size and loading density are of crucial importance. The effect of group size and composition on livestock during transport is little known and needs research.

2.2.2. Grouping and space requirements

The European Convention for the Protection of Animals during International Transport (Council of Europe, 1972) states which animals may be grouped together and for which animals it should be strongly avoided. But it is not only grouping which is of great importance for transportation since space requirements are of similar significance. Unfortunately, the European Convention does not give any information concerning the space needed during transportation.
Many authors observed that unfamiliar animals start fighting if they are grouped together. As described previously, fighting during transport can be reduced if animals are kept together for some time before loading. In some countries, before export, animals have to be kept for a certain time period in lairages and in the course of loading prearranged animals have to be grouped together and not mixed with other animals.

Horses

Horses rest in a lying position only if they are familiar with the environment. They are also able to rest while standing for a longer time. Since there is probably no familiarity with the environment during transportation, the expert opinion recommends an area of 1.75 m^2 (0.7 x 2.5 m) for adult horses transported. Because foals (up to 6 months) usually lay down after a short period of transportation, a minimum space requirement of 1.4 m^2 (1.0 x 1.4 m) is considered as necessary. Young horses (6-24 months) show the need to lie down after having been on transport for more than 48 hrs. For those a minimum space requirement of 1.2 m^2 (0.6 x 2.0 m) or a minimum laying area of 2.4 m^2 (1.2 x 2.0 m) is recommended (Gutachten, 1977).

Cattle

For cattle German experts recommend, depending on live weight, for calves up to 150 kg 0.33 - 0.70 m^2, for calves and young cattle from 150 to 300 kg 0.7 - 1.10 m^2, for cattle between 300 and 700 kg of live weight 1.10 - 1.60 m^2, for pregnant and lactating cows 1.30 - 1.70 m^2 and for old bulls 1.75 - 2.00 m^2 per animal. Group size of young calves (40 - 80 kg) should not exceed 25 - 30 animals, calves (80 - 150 kg) 15 - 25 animals, and older calves (150 - 220 kg) and young cattle up to 300 kg live weight 10 - 15 animals in lorries and 20 - 25 animals in a train wagon. Group size of pregnant and lactating cows and old bulls should consist of not more than 5 animals in lorries and 10 - 12 animals in a train wagon. These recommendations are based on practical experience not on scientific research.

Pigs

If the loading density is too high, this may cause unnecessary suffering for the transported animals. However, if the loading density is too low, standing pigs cannot support each other and animals will fall down if sudden movements of the vehicle occur. Information on the best loading density is absent. Schütz (1975) observed that pigs lie down during transportation. To make it possible for all pigs to lie down at the same time an area per pig of 100 kg live weight of 0.5 m^2 must be provided. This demand is underlined in experiments by Von Mickwitz (1982), who found that a high animal density (less than 0.4 m^2) leads to an increase of body temperature, heart rate and respiratory rate. This means higher stress for the animals and results in a higher amount of PSE meat, because animals were slaughtered with high body temperatures (up to 41°C).

Von Mickwitz (1982) concluded the limit for loading density for slaughter pigs (100 kg live weight) is 0.5 m^2. The Meat and Livestock Commission (1974) confirms the recommendations for slaughter pigs in other countries (0.5 - 0.6 m^2), but indicates that a range from 0.4 - 0.5 m^2 would be adequate for baconers. The same source holds the opinion that variations in weight of pigs, weather conditions, vehicle design and construction preclude the recommendation of precise loading densities.

Sheep

Sheep should be transported in groups, which do not contain more than 20 animals. The groups should be separated on the transport vehicles by fences. Rams have to be transported as single animals, if they are not transported with sheep of their own herd (Hinrichsen., 1979). Platt (1982) reports that on ships sheep are kept in pens with about 50 - 60 heads. Müller (1982) who travelled with sheep from Australia to the Middle East by ship, considered an average floor space of 0.30 - 0.33 m^2 per animal to be sufficient. According to this author, densities of 0.25 to 0.45 m^2 had no influence on death rate during transport. Sheep should not be too losely packed, because this results in bruising whilst the vehicle is in motion.

There is much conflicting evidence on journey times. Schmidt and Lengerken (1980) found death rate increased with distance to the slaughterhouse whereas Augustini (1976) found pigs in "a better shape" after transportation over 300 km as against 30 km. Although in national and international legislation loading densities are quoted for various species, weights and ages of animals, group size is not mentioned despite its obvious importance. The regulations on loading densities are based more on opinion and negotation than on scientific information which can only come after planned research.

2.2.3. Feeding and watering

The European Convention for the Protection of Animals during International Transport (Council of Europe, 1972) states: "During transport animals shall be offered water and appropriate food at suitable intervals. Animals shall not be left more than 24 hours without being fed and watered. This period may, however, be extended if the journey to the destination where the animals are unloaded can be completed within a reasonable period". Whether this period has been based on physiological data is doubtful.

Horses

If horses are transported from Poland to Italy by rail, they are watered at the border station in the Federal Republic of Germany after having left the German Democratic Republic. The transport has lasted about 18 hours then. The description of Weichert (1981) shows that the horses are unloaded and some start to drink right away on the platform. Others, however, are much too excited to drink and have to be walked up and down the platform for about a quarter of an hour before being able to drink. If horses are found sick or injured, they are excluded from the transport and slaughtered in the nearest abattoir immediately (Bornkessel, 1982). Horses imported to Germany and transported by truck reach their destination within 24 hrs, so they are not fed and watered. Horses in transit to France are watered (Geyer, 1982).

Cattle

Bisschop (1961) studying feeding and resting behaviour of cattle during breaks in long journeys, showed a consistent pattern of behaviour in the cattle. The cattle were unloaded into pens containing water and lucerne hay. The animals spent a short period of intensive feeding, during which they ingested about 2 kg of hay. A short period of fidgeting, walking around, desultory picking at the remaining food, drinking, possibly eliminating and finally lying down to rest, ruminate and sleep followed. The period of rest lasted up to an hour. After that, when the animals felt hungry again, they were restless and moved about searching for food. Sutton et al. (1967) found that under similar conditions cattle showed a marked preference to walk around slowly before settling down to eat and drink. During a combined journey of truck and rail described by Friend et al. (1981), calves started immediately eating hay and drinking water after loading into the railcar, reflecting the deprivation during the 750 km journey by truck to the railroad station. The calves continued eating and drinking regardless of the smoothness of the ride. When the car was standing still, consumption was greatly reduced as calves lay down to rest. When the car started moving again, the calves stood up and commenced eating and drinking. Apparent hay (5.1 kg) and water (21.1) consumption per head was normal. According to Jackson (1974) during a 24 hr. air journey, Hereford cattle browsed at hay but did not drink water.

These 4 reports suggest that cattle do eat and drink during transport, if the movements of the means of transport are not too vigorous (Friend et al., 1981). However, if they are, cattle have to be unloaded in order to be able to eat, to drink and to rest (Bisschop, 1961; Jackson, 1971); as is the case with horses.

Pigs

If slaughter-pigs are transported from The Netherlands via Belgium and France to Italy, they hardly make use of the drinking nipples, made operational at the border between France and Italy after having been transported for at least 24 hours (Van Putten & Lambooy, 1982). One could imagine several reasons for this behaviour. The assumption that they are not thirsty is a very simple one. However, there may be other reasons, which are much more complicated to deal with.

One could for instance assume, that these pigs did not use the drinking nipples, because they were not familiar with them. This possibility was tested by comparing the drinking behaviour of 160 pigs used to drinking nipples with that of 80 pigs being watered with troughs. There appeared to be no difference between the pigs with nipples and the ones with a trough. However, pigs under a heavy stress did drink very little in contrast with pigs not being stressed. The latter did drink relatively much, no matter whether they were fed or not. The time before, during which they were not watered (24 hrs. of 48 hrs.) did not influence the amount of water intake (Lambooy, 1982).
It is not very likely, that the pigs drinking little were not thirsty. Inspection of the blood and carcasses of the slaughtered pigs showed a certain amount of dehydration. Nevertheless the claim is made that these pigs were not thirsty because they converted their body fat into water. Another observation does not support the assumption that pigs in transport are not thirsty. Many pigs for breeding purposes are transported by lorry from Belgium to the airport of Amsterdam. These transports last at least five hours. At Schiphol airport the pigs are unloaded and, once on the ground, are watered from water troughs. Under such circumstances they appear to be really thirsty and are eager for water (Van Putten & Lambooy, 1982).

There may be another reason for not drinking from the drinking nipples during a stop at the French-Italian border. Friend and others (1981) report the behaviour of calves during a rail transport of 2.5 days. Food and water were available during the whole transport. However, during the stops the calves did neither eat nor drink. They used these occasions to rest. Maybe transported pigs also are too tired to drink during the stops and simply rest.

There is no reason at all to presume that horses are more stress susceptible than pigs. If this applies also to pigs, it would mean that pigs on their way to Italy have to be unloaded from time in order to let them drink. This would be in accordance with the procedure we use with horses and also with the necessity to unload cattle to let them eat and drink. The necessity to unload depends largely on whether the vehicle moves in a very unpredictable way like lorries, or provides a more or less stable environment enabling the animals to rest, to eat and to drink, like on ships in calm water and sometimes on trains. Jackson (1973) accompanied a transport of 120 pigs (age between 6 and 9 weeks) from England to Italy by ferry and railroad, which lasted 7 days. During the journey 508 kg of creep feed and 10,910 l. of water were consumed by the pigs.

Sheep

According to Geyer (1982), the duration of sheep transports by road from the middle and western parts of Poland and from Eastern Germany last no longer than 24 hours. It has to be supposed that sheep transports from the East of Poland and from the Soviet Union do not reach destinations in France within 24 hours. For this reason sheep from the Soviet Union had to be unloaded, fed and watered. If the animals arrive at their destination place however within a "reasonable time" (according to Geyer, 1982, not longer than additional 6 hours) they are not unloaded. The author assumes that the unloading of 400 sheep out of multiple floor trucks causes more stress to the animals than a duration of the transport of about 30 hours.

Vigorous movements of the vehicle prevents animals from drinking. During stops animals often prefer resting to drinking. Therefore it is useless to install expensive watering devices without giving the animals a real chance to consume the water.

The requirements for "a real chance" differ from species to species. For horses it means unloading. For other animals research is urgently needed.

2.3. At the abattoir

2.3.1. Unloading and handling

Arriving at a slaughter-house at the end of the journey the animals should be unloaded immediately. Animals should not have to wait in a standing transport vehicle. For unloading the same basic rules should be applied as for loading. Grandin (1981, 1982b) claims that unloading chutes should be constructed differently from those used for loading. A chute used for unloading any type of livestock should be wide and straight to provide a clear, unimpeded path to exit. If the chute is curved too sharply, the animals may refuse to leave the truck because the chute appears to be a dead end. Disembarkation of sea-transported livestock can also be hazardous for the animals. The water-level at ports affects the angle of the gangway on which the cattle are driven off the ship; a correlation was found between the steepness of the gangway and the damage to the animals (Müller & Von Hörsten, 1982).

Cattle

According to Drawer (1971) hurrying too much while driving cattle on slippery ramps and ways may cause painful fractures of vertebra and other bones, and bruises. At abattoirs special vehicles should be available for injured animals. According to Grandin (1979,1980b) livestock often get injured while they are being loaded or unloaded. Leg and foot injuries can occur if the truck is not positioned properly against the loading dock. In cattle 66% of the bruises of the loin area occur during loading or unloading of trucks. The double deck trucks which unload through the side instead of through the rear may be a factor in the high percentage of bruised loins.

The major problem in such trucks occurs when cattle are being unloaded from the top deck since they have to walk down an internal ramp from the top deck, negotiate a 90° turn, and walk out the door at the bottom of the ramp. If the animals become excited or are rushed by the handlers, they can dumb their loins against the side of the door.

Pigs

For unloading pigs various types of platforms are used. The upper deck of the lorry is nearly always unloaded first and because the unloading platforms have been adjusted to the height of the lower deck, it is necessary to bridge a difference in heigt of about 1 m when unloading the upper deck. Pigs prefer to walk up a slope rather than down one. They become frightened when they have to walk down the slope. The truck drivers are usually in a hurry, so that the pigs tend to be handled with a lack of patience and often with undue force. The pigs are driven down the slope with the help of an electric goad. Those pigs that cannot get up, because of cramp or because of disease or injury, will be tramped underfoot during the process. They will have to be dragged off the truck. This is usually accompanied by beating or kicking or they are dragged across the floor, often with a chain attached to one of the hind legs (Scientific Commission on intensive livestock., 1978).

At the end of the journey, which often means after two or three days of travelling, pigs may not be too well received. They may arrive at night and then have to wait in lairage until the next day to be slaughtered. They may even have the misfortune to arrive on a Saturdaynight and in that case they have to wait a whole weekend. Mostly they are showered after arrival, but sometimes such facilities are not present.
After transport pigs should be showered, but not continuously. They prefer 2 showers of a quarter of an hour to uninterupted showering during a two hours rest at the slaughter-

house (Van Putten & Lambooy., 1982).

Sheep

According to the Meat and Livestock Commission (1974) unloading facilities for sheep at the lairage should provide unloading ramps to reduce steepness of lorry tailboards. Adequate lighting is necessary in the unloading area during the hours of darkness. The use of "Judas-sheep" to lead sheep from transport vehicles to lairage pens would reduce handling and stress to a minimum.

Poultry

Gerrits & De Koning (1982) describe the unloading of broilers. After arriving at the slaughter-house the broiler stacks are de-stacked. Only a small number of slaughter-houses are equiped with a mechanical de-stacker. In many cases the full crates are dropped onto a roller conveyor; the top crate from a stack falls down about two meters. During the manual de-stacking the crates are not always kept in a horizontal position, so that sometimes all broilers are pressed together along one side of that crate.

In order to avoid delay in unloading then transportation should be well planned. Delayed unloading is unacceptable if animals have been transported in a way nobody can take care of them, or in vehicles without adequate ventilation during stops. Because the animals are tired after long journeys special arrangements should be made to prevent them from stumbling and falling down ramps.

2.3.2. Immediate slaughter or lairage to precede slaughter

According to the European Convention for the Protection of Animals for slaughter, animals shall not be taken to the place of slaughter unless they can be slaughtered immediately. Animals which are not slaughtered immediately on arrival shall be lairaged. Kenny and Tarrant (1982) noted that a so-called rest period in practice is usually unavoidable in order to ensure the continuity of the supply of animals for processing. Several authors doubt that animals are able to rest or recover from the stress of transport in the given types of lairages.

After transportation animals often are placed together with strange groups in lairages. Grandin (1979) and Kenny and Tarrant (1982) investigated mixing of unfamiliar groups of cattle. This caused a high level of agonistic behaviour and resulted in a high level of physiological stress. Cattle became stressed if they were sorted and regrouped more than once during a 48 h period. Mixing was counterproductive as it prevented the animals resting and they frequently become exhausted and sometimes injured. According to Kenny and Tarrant (1982) the behavioural response to mixed penning is most obvious and intense among young bulls. They observed that the animals showed an immediate and high level of aggressive and mounting activity which gradually abated over a considerable number of hours, as the social hierarchy was established and the animals became exhausted. The total number of behavioural interactions per minute at 30 min after mixing was 1.29; after 150 min 1.21 and after 240 min still 0.95.

Kilgour (1976) reported that the shape of pens is an important factor. Cattle, like pigs and sheep, prefer to rest along the fence, also square pens mean that cattle are more crowded than in long, narrow pens. Bulls start to fight, if the distance between animals is less than 5.5 m, even in formed groups.

Bulls are very sensitive to disturbance and greatly stimulated by seeing other socially active cattle, whether fighting or mounting. Mixing strange bulls can best be carried out towards evening, immediately before feeding.

Dark-cutting in cattle which spend the night in the slaughter plant stockyards can be practically eliminated in steers if the animals are kept unmixed in the stockyards. Bulls should be slaughtered as soon as possible after arrival. Loads of cattle which have been shipped for long distances or through bad weather should be allowed to rest for one or two hours only and then slaughtered (Grandin, 1980).

The effect of penning of steers before slaughter on the occurrence of dark-cutting meat was investigated by Grandin (1979). She described observations on 423 steers penned in groups at a show ground, transported by road for 5 h to an abattoir, where they were again penned in groups until slaughter. The animals were treated as follows:

No of animals	Treatment	% DFD
80	Transported immediately penned and slaughtered on arrival at abattoir	0
45	1 night penned at show-ground, slaughtered on arrival	0
84	2 nights penned at show-ground, slaughtered on arrival	3.5
29	3 nights penned at show-ground, slaughtered on arrival	10
79	1 night penned at show-ground, 1 night in lairage	(figure missing)
109	1 night penned at show-ground, 1 night in lairage	17

Grandin (1980) points out that one of the reasons the incidence of dark-cutters is lower in the U.S. (0.5%) than in England (8-10%) is that the majority of the fed steers and heifers are handled in large homogenous groups and not mixed with strange animals. Investigations indicated that mixing strange steers together only once would usually not cause dark cutters if the animals were slaughtered within 24 h after mixing. If strange steers were mixed together, and then re-sorted, so that their social hierarchy was disturbed two or three times within 48 h prior to slaughter the incidence of dark cutters rose sharply.
McVeigh et al (1982) studied muscle glycogen breakdown during mixed penning of young Friesian bulls. Mixing was accompanied by a high degree of physical activity, which gradually lessened during the 6 h stress period. Physical exchanges between the newcomers and the established group consisted of aggressive butting and pushing, and frequent mounting. Physical activity was probably accompanied by emotional arousal in response to a novel and threatening situation. Stressed bulls showed increases over controls in body temperature (P 0.001), heart rate (P 0.001), serum nonesterified fatty acids (P 0.05) and plasma creatine kinase (P 0.01). Muscle glycogen content fell during stress to 41% of the value for the control animals (P 0.001). Recovery of muscle glycogen concentration to resting values took 3 to 7 days under favourable conditions (McVeigh et al 1982; McVeigh and Tarrant 1982).
Augustini (1981) investigated the effect of different waiting times and group compositions in the lairage for bulls raised in loose yards. He found that lengthening the waiting time on the day of arrival and also prolonging the time in lairage till the next morning was closely associated with an increase of dark-cutting beef in M. semimembranosus. Only if the animals were slaughtered immediately after arrival was dark-cutting avoided. When bulls were mixed together, waiting times up to 90 min resulted in some incidence of high ultimate pH values.

The frequency of dark-cutting in beef was lower in groups which were not mixed together. In these groups a prolonged waiting time (at least 1.5 to 3 h) was necessary to produce this quality fault. The pH value at 48 h post mortem was closely correlated with glycogen concentration and meat temperature (both measured in *M. semimembranosus* at 30 min post mortem) but not with the concentrations of creatine phosphate, ATP and lactate.

Kọl'k and Kol'k (1972) studied the influence of different starvation times and overnight penning in lairages on the meat pH values. The pH value was measured on a total of 305 cattle. Starvation times were from 0 to 28 h. Starvation did not improve the pH value. On the contrary, for animals kept in lairage overnight, the number of carcasses showing pH values above 6.2 was twice as great as in animals slaughtered immediately after arriving.

Geschwindt and Ehinger (1979) studied the influence of different waiting times before slaughter in broilers. For this purpose the animals were placed on the ramp of the slaughterhouse for 0 to 4 h. The ambient temperature was 20 to 24° C, inside the boxes it was 13° C higher than outside. The concentration of carbon dioxide was between 0.2 and 0.3 volumes per cent and the concentration of ammonia was 4 ppm at the end of the experiment. The weight loss after the first hour was 2.6 per cent and after 4 h was 3.75 per cent. By increasing waiting periods up to 3 h the tenderness of breast and thigh meat was decreased. The water binding capacity was at a minimum after 3 h of waiting before slaughter. Blood parameters including haematocrit, haemoglobin, serum protein, serum lipids and serum cholesterol indicated an increasing stress situation.

3. Specific criteria

Methods of transport

Animals are transported by road, rail, sea and air. Each method has its unique advantages, the most common method of transport of farm animals within or between European countries is transport by road. National legislation within Member States ensures minimum construction requirements. For example, the Agricultural Department (1978) state that livestock vehicles must conform to statutory construction and maintenance standards. These are intended to ensure that animals do not get injured or suffer in vehicles which are poorly designed or maintained or not properly equipped. The requirements cover the provision of:

(1) floors constructed so as to give a proper foothold to the animals
(2) interiors which are free from dangerous projections
(3) ramps for loading and unloading constructed according to certain specifications.
(4) suitably designed and constructed partitions used to separate the animals
(5) rigid sides and suitable roofs to vehicles, to protect the animals from the weather
(6) adequate ventilation
(7) easy access to the animals
(8) arrangements to prevent overcrowding, including specifications of maximum pen sizes.

Several authors believe all transport vehicles have to be equipped with lights. These requirements apply for all means of transport.

3.1. Road vehicles

Road vehicles are the main transport method to carry pigs. Pigs are transported in specially designed trucks which have two storeys, with a lower and upper deck; some trucks may have three decks. Pig transporters are designed to carry between 75 and 100 pigs at a time (Scientific Commission on Intensive Livestock). Van Putten and Lambooy (1982) recommend a distance of 3 m between partitions in a lorry.
According to the Meat and Livestock Commission (Technical Bulletin N° 14,1980) some vehicles have an inadequate head-room which accentuates overcrowding. It is assumed that precise recommendations for heights between decks in pig vehicles are not possible as there are considerable variations in the size and weight of pigs carried. However, as a guide each animal must be able to stand up and there should be sufficient head-room for the proper circulation of air. Each pen on each floor should be easily accessible to personnel. But this is difficult to achieve due to the low distance between the decks and the loading density.
Van Putten (1982) states that vehicle loading ramps are generally at an angle of 30° to the ground. This is, as mentioned earlier, too steep for pigs. The loading ramp should not exceed an angle of 15°, which makes the ramp too long to be a part of the lorry and therefore should be equipment at the fattening farm. According to Sybesma et al. (1978) lorries are now available with hydraulic lifts, which makes loading and unloading less stressful for the animals. A claimed disadvantage of hydraulic lifts is that the process of loading and unloading is more time consuming compared with other methods.
About 10 years ago containers to carry pigs were discussed. Van Putten (1973) and Wohlfahrt and Schröter (1974) reported good results using this method in respect of deathrate; pigs also arrived far less stressed at the abattoir. The higher organizational requirements of this method probably meant it never became popular.

A continuing problem seems to be the proper ventilation of the lorries. According to Van Putten and Lambooy (1982) pigs are very hot after loading on a lorry because of the physical and psychological stress. The authors state that ample ventilation-openings are vital even for transport lasting only some hours. There are many publications on the influence of high temperatures, but no information about the impact of very low temperatures on pigs in long duration transportation. One solution could be to equip lorries with air conditioning Horses, cattle and sheep (depending on the fleece) are less sensitive to cold conditions than pigs, although these species have to be protected from inclement weather.

In international transport cattle are carried in trucks with two decks holding about 70 bulls (Geyer, 1982). For trucks transporting sheep the Meat and Livestock Commission (1980) recommends adequate partition points, ideally at 30 cm centres, should be provided. Partitions should be provided for at least every 2.4 m of vehicle length. The top deck of three-deck vehicles should be totally enclosed. To reduce the slope of the deck, lorries should be built on either the stepped frame principle or with a lower than normal turntable height. According to Geyer (1982) one lorry can carry 300 to 500 sheep or lambs. The same author reported horses intended for slaughter are transported by trucks carrying 18-22 animals.

According to Löliger (1974) and Löliger and Torges (1977) transportation of poultry destined for slaughter is carried out nearly exclusively by road. Poultry (broiler, poulards, finished laying hens) are transported in special containers which have openings for ventilation on each side. The height is between 23 and 26 cm. The density in the container depends on the weight of poultry: up to a live weight of 1250 g the area provided per animal is 250 cm^2, up to a live weight of 1500 g an area of 320 cm^2 and for animals heavier than 1500 g an area of 360 cm^2 is recommended.

Each cage contains 12-20 broiler or 10-17 laying hens.
The loading capacity of a lorry with trailer is between 10 and 15.000 broiler and laying hens, or 1000 to 1200 turkeys. These authors expect the duration of transport of broilers to be between 3 and 6 h and for finished laying hens 12 to 15 h in Germany.
According to the same authors turkeys are transported for both short and long journeys with distances up to 600 km. Turkeys are transported in metal containers (each for 6-12 animals) in 5-7 tiers on the lorry. The sides of the containers consist of bars or fences that allow proper ventilation. The tiers of containers are divided by solid horizontal partitions.

In multiple deck lorries concern is expressed about the droppings falling from the upper decks on to the animals beneath, and from the lorry on the road. Animals become wet and cold from the faeces of their conspecies. Droppings lost on roads are not desirable if there is any danger of pathogenic contamination.

3.2. Roll-on/roll-off ferries

From the United Kingdom the greatest proportion of livestock exported for breeding, further fattening and slaughter goes by roll-on/roll-off transport. Five veterinary officers accompanied livestock from certain major English ports for a six-week period. They published in detail on this method of transport (Brown et al. 1976). Livestock lorries were loaded as late as possible on the ferries. These lorries were placed nearest to fans or open spaces, where the vehicles had the best ventilation. If the hold was not full, the vehicles were given extra space all around, or if the hold was full, they were placed in the best position available. The best positions were those in the centre since the ones on the sides of the ship were not this good. Problems can occur in ventilation, probably due to a breakdown in communication, or lack of knowledge, rather than an actual mechanical fault. Temperatures in the hold varied on different trips from 14° C to a maximum of 24° C. These were independent of the external weather conditions. Temperatures up to 26° C were recorded. The higher temperatures usually occurred in the forward pens of the upper tiers. If two or more rows of vents were provided, ammonia was not usually experienced. In aluminium containers with limited ventilation, ammonia was frequently noticed.

All vehicles were provided with access doors; so all pens were accessible to some extent. Some vehicles had safety grills inside the doors. Few lorries had two metal cross bars inside each door to prevent animals falling out when the doors were opened. Unloading time from ferries was generally very rapid and livestock lorries were unloaded as soon as possible.

3.3. Trains

The European Convention requiries that railway trucks shall be marked, covered and constructed to prevent escape and ensure safety and adequate ventilation.

Vehicles shall prevent escape, ensure safety and have a roof and tying facilities. Partitions shall be rigid. The advantage of transportation of livestock by trains is that they are accompanied by personel. For long duration transportation they carry feed and in some cases water. But if the water is not permanently available livestock are provided with it on stops during the journey. Another advantage of transport by train is that trains in transit are controlled permanently and the position of the train is always known. In the accompanying travel documents the locations, time and duration of feeding and watering are noted. About one fourth of the horses exported from Poland are transported by railroad. The transports are carried out by the German or the French Railroad Administrations. The area of these wagons is 25 to 33 m^2. The middle of the wagon is reserved to feed or inspect so that the area is 2.4 to 2.75 m^2 per horse. Eight to ten horses are loaded per wagon in a right angle to the driving direction.

Only sports horses are loaded in the driving direction. Ventilation wings, depending on the weather are totally or partly opened and the sliding door is 15 to 35 cm open (Bornkessel, 1982).

Jackson (1973) reports the transport of 120 piglets from the United Kingdom to Italy in a railcar converted into 4 pens each of 4.65 m^2. A central area between the doors of 2.74 x 2.44 m was left for feed, water and bedding for the pigs. The journey lasted 7 days and included 2 days of waitingtime. The only serious problem was with ventilation. The ventilators could not be adjusted from inside the railcar so the choice was between cold or condensation and Jackson (1973) believes that if plenty of food is available it is better to keep the ventilators open.

3.4. Fitted vessel

The European Convention incorporates specific regulations about sea transport. The articles 25 to 30 of the Convention state, that animals should be tied, or properly accommodated in pens or containers, with adequate passageways between to allow access. All parts of the vessel where animals are accommodated should be provided with drainage and kept in a sanitary condition. The number of attendants shall be sufficient. The vessel shall be provisioned with sufficient drinking water and appropriate foodstuffs. Provisions for the isolation of ill or injured animals are required.
Dow (1976) states that there are matters for concern due to transport by sea. First, an increasing number of ships engaged in livestock import and export, which once flew the British flag, are passing under flags of other nationalities. This might be true for several other member states of the EEC also. Second there is growing evidence of ships' captains sailing under owners' order but contrary to their best judgement on the suitability of conditions for their livestock cargoes.

Transport of horses by sea was important for military reasons as a means of mass transportation in the past. Sea transport of sports horses has been replaced by airtransport. Except in countries, which prohibit the import of horses by air for reasons of controlling diseases. Horses are kept on ships in containers of the following minimum size: 85 cm wide long, and 200 cm high. The containers are arranged at right angles to the sailing direction, in order to balance the dashing of waves and the rolling of the ship. The passages between the containers have to be 90 cm wide to make a change of the position possible during the journey. The horses are loaded on a gangway which should have sidewalls of 150 cm (Hinrichsen and Körner, 1978).

World Society for the Protection of Animals (WSPA) (1982 a) field investigations into the bulk transport of horses for slaughter showed a high proportion of injuries when the horses were examined at the place of disembarkation. In some instances the unsatisfactory mode of transport, i.e. bad design features of the transporter and equipment, is clearly the cause of these injuries. However, there have been occasions when the mode of transport was clearly not a fault and the causes remained obscure. Ethological studies into equine behaviour and the effects of stressful stimuli in horses indicate that horses react substantially differently from domestic farm animals, particularly in relation to bulk transport. In this respect; a special case may well be to preclude horses from this type of transport unless the most stringent safeguards are applied - according to the opinion of the WSPA. Horses transported in bulk for slaughter purposes are usually tethered alongside each other or in close proximity with each other within the confines of pens. While these arrangements permit desirable bodily contact to be maintained, the individual distances required between animals for peaceful coexistence is not provided. The results are bite wounds.

According to Müller and Von Hörsten (1982) sea transport is the cheapest way to transport cattle. Cattle transported in these ways as well as those reported by Von Hörsten (1979) are destined for breeding. Increasing ambient temperatures led to higher body temperatures, respiratory rates and pulse rates in animals transported on the deck of the vessel.

Sheep are transported by sea from Australia to the Middle East. Several of the ships used are carrying 90.000 to 100.000 sheep on six decks. Five to six stockmen take care of the animals supervised by a livestock officer who is responsible for nutrition, health, treatments, records and the monitoring of temperature and ventilation levels (Platt, 1982). Müller (1982) has also accompanied these transports. He described the climatic conditions. The temperature increased from 21°C to 36°C on the E-deck and the relative humidity from 65% to 95%. NH_3 - concentration varied between 7 and 35 ppm and CO_2 - concentration between 0.08 and 0.1 0/00. Strewing superphosphate reduced the NH_3 - concentration from 15 to 4 ppm and in one transport reduced the losses.

3.5. Transport by aircraft

Air transport is the most careful, but the most expensive method to carry animals. It is possible for an animal to be taken to any part of the world in a matter of hours, thus increasing its survival potential. Millions of animals are now carried by aircraft each year, but, because of its high costs, air transport is more widely used for the movement of zoo animals, wild animals for laboratories, and valuable domestic animals, such as racehorses, and breeding animals, than for the routine transport of livestock (Halls, 1978). Transport by air shall be described even if animals of high value are transported by this method so far.

Regulations for horses transports are provided in the Live Animal Regulations of the International Air Transport Assiciation IATA).

According to Hinrichsen and Körner (1978) normal planes, freight or transformed passenger planes serve as the means of transport. The number of horses transported by a plane depends on the type of plane. The animals are loaded in containers outside the aircraft. As soon as an animal is in a container, it is secured by a belt that runs across its back. This prevents the mounting of the horses in the container. The loading of the container is carried out with the help of a special lifting platform, which conveys them up to 8 m into the cargo department. The critical stages on the flight are the take off and landing. The horses calm down as soon as the flight altitude is reached.
Similar observations were made by Jackson (1974) with cattle; resting behaviour seemed to increase in the animals as the journey continued. The transport of one-day old chicks by air is reported by Hoogerbrugge and Ormel (1982). Generally 3 to 12 hours after hatching the chicks are transported by truck to the airport, then the boxes are put in pallets or directly loaded into the belly of the aircraft. The time between loading and take off has to be as short as possible since during loading there is usually only natural ventilation in the aircraft.
In modern aircraft heating is present in all compartments. This means that only in the case of mistakes or accidents is the death of 1-day old chicks caused by low temperatures. During the flight the authors collected data about temperature values inside the plane. The data show a large difference in temperatures found in boxes located at different places. Sometimes the authors found temperatures exceeding 35°C. These high temperatures are dangerous for the chicks. The heat produced in the chick box can only be removed by convection or ventilation. As most chick boxes are surrounded by other boxes the net heat loss by ventilation is about zero. So the only possible way to reduce the heat is by convection. The loading configuration of the boxes depends on the size of the boxes and on the compartment in the aircraft.

To prevent boxes from moving they are often stacked like bricks. This means that air circulation between the boxes is limited and heat removal is reduced.
Much better ventilation is possible when there is an open space between each stack of boxes. But this will render the adherence between the individual boxes to be poor, making the use of so-called "spacers" necessary to keep the box structure rigid.
In most aircraft the fresh air inlet is situated at the top of the compartment and the outlets at the side wall or at the loading floor so that the ventilation system does not suit the transport of large numbers of chicks. The authors are of the opinion that the present ventilation system is inadequate for animal transport, which involves a layered system of stacking. For chicks and poultry the removal of warm air is less than the ventilation rate of the aircraft would suggest. Müller (1978) calculated ventilation rates per kg bodyweight for the air transport of the different species of domestic animals, which will allow a satisfactory transportation of these animals. As ventilation-rates during flight are smaller than at ground level it is necessary to have additional ventilation equipment provided during loading etc. The temperature of the cabin is easy to keep about 18-24°C while the ambient temperature outside is about -50°C. Critical conditions arise in the course of landing and on the ground itself, where the temperature of the cabin or cargo department cannot be cooled down by inlet of ambient air of high temperatures. These situations occur in the tropics as well as in temperate zones if the loading density of the aircraft is too high.

In all transport methods satisfactory ventilation is crucial and this must function effectively during all climate conditions and for the different species sex and age; having a direct relationship to group size and stocking density.

4. Economic, marketing and social considerations

Economic effects of transportation of animals include losses caused by death, bruising, lower meat quality and weight loss. Whilst in most countries transport deaths have decreased recently reports of lower meat quality caused by stress during transport have increased. Further considerations of economic aspects include comparisons of the means of transport and the advantages or disadvantages of slaughter near the point of production. This report does not deal with the economic aspects of the entrepreneurial considerations of international trade in slaughter animals.

4.1. Death rate and injuries

Death rates in international transport seem to have decreased recently under western European conditions. One of the reasons might be that animals intended for export are selected carefully to pass the veterinary inspection and certification of fitness for transportation.

There might be another reason, however. There is the possibility that the remarkably low death rate could be a result of an insufficient registration of major fatalities. Everyone who is engaged in transportation of livestock knows cases of high mortalities where the authorities were notified too late or for other reasons were not able to react. Examples of such cases are high death rates in cattle caused by prolonged waiting times in North African ports where the cattle were not unloaded because of Ramadan; calf losses in France were caused by an unsuitable lorry, calves broke through the upper decks; high sheep losses were caused by excessive driving time without a break because the driver got lost. But the statistics in which such cases are registered are unknown.

4.1.1. Mortality and injuries in horses

According to Bornkessel (1982) the loss of horses transported by train from Poland to France is on average 0.8% observed at the German border. Geyer (1982) found from a total of 27,000 horses transported by road from Poland to France in 1980 five animals were dead at the border station of Helmstedt, and six horses had to be excluded from further transport because of severe injuries or sickness.

4.1.2. Mortality and injuries in cattle

Transportation can result in high calf mortality, especially when the animals are transported at an early age (Stephens, 1982). For example, calves younger than 14 days of age that were transported over long distances have shown a mortality rate as high as 23% (Staples and Haugse, 1974). Calves are susceptible particularly in the first days of life or during long distance transport (Barnes et al. 1975). For example in several shipments of calves by air from the USA to Italy in 1964, mortality during shipment was very low, but heavy losses occurred during the first 8 days after transport, in some cases more than 9% (Claxton, 1968). Rodenhoff and Schonherr (1971) found that transport mortality in cattle carried by rail was twice as high as it was during road transport. Deaths of cattle during road or rail transport were estimated at 0.01% and the most frequent causes of death were suffocation or cardiac insufficiency (Istvan, 1979).

Apart from these findings, most of the information on transport mortality in adult cattle is related to sea transport. Losses in cattle exported from Australia in 1956-1958 were caused by heat stroke, high humidity and injuries sustained during excessive movements of the ship (Lavers, 1959). Contributory causes were overcrowding, inadequate drinking water, incorrect feed and failure of cattle to adapt. During shipment of 350 cattle from New Zealand to South East Asia 102 died (Donaldson, 1970). Andersen and Lowe, (1971) concluded from a study of shipments of cattle by this route that mortality could be reduced simply by providing adequate ventilation and water supply.

The effect of overcrowding has also been demonstrated during the sea transport of 5275 breeding cows from West Germany to Morocco in fourteen shipments between November 1974 and March 1975, mortality was 1.3% in pregnant cows and abortions accurred in 4.5.% (von Mickwitz et al., 1976), of 5509 pregnant cows in 23 shipments, 0.69% of the animals died and 4.64% had abortions of those transported on deck, whereas 2.0% died and 6.92% had abortions when the animals were kept below deck, (von Horstein, 1979).

Bruises are traumatic injuries without penetration of the skin, where tissue and blood vessels are damaged to such an extent that there is extravasion into the surrounding tissue (Petersen, 1978). The economic loss resulting from bruises in the U S livestock industry was estimated at approximately § 46 million annually and of this § 22.4 million was in cattle (Grandin, 1980). Bruised meat cannot be used for human food. Bruising results from an animal striking its body against a sharp object or being hit by an abusive or careless handler. Studies in Australia indicated that horns are one of the major causes of bruises, bruising being almost doubled in groups of horned cattle when compared with groups of polled cattle. Tipping did not reduce the bruise losses. In a further study Grandin (1981) found that cattle which had been handled roughly during weighing and loading at the feed-lot had 15.5% bruises causing price discount. Cattle which had been carefully walked onto the scales and trucks with a minimum of excitement had only 8.35% discountable bruises. The author observed that putting just one or two extra cattle on a truck can double the amount of bruising. The highest percentage of bruises were located in the valuable loin area. A total of 45% of the bruises occurred on the loin, 23% on the back, 2% on the rump, 15% on the flank, 11% on the rib and 4% on the shoulder. Overall 10.5% of cattle surveyed had discountable bruises, and 5% of them had discountable loin bruises, 2.3% had loin bruises which were so severe that they extended all the way through the carcass.

The cattle in this survey had been trucked 80 to 240 km (Grandin, 1981).
Bruising was more frequent in cows and resulted in higher average trimming losses than in steers (2.6 kg versus 1.6 kg, respectively), (Yen, 1978). The weight of bruised tissue trimmed off the carcasses of cows was related to the length of transportation and increasing fatigue may be important in that respect.

Meischke (1975) found a connection between bruising and the number of stops in a train journey. Bruise trim on equal journeys was 0.89 kg/carcass when there were four stops versus 1.2 kg/carcass when there were 10 stops.

The Australian Meat Board reported that 10% of all cattle surveyed were downgraded for bruising (Dow, 1976). A survey in Australia in 1971 indicated that beef losses due to bruising were valued at about §17 million (Thornton and Gracey, 1974). Three trials, each with 100 bullocks previously grazing improved pasture, compared bruising in cattle starved for 24 and 48 h before transport for slaughter. Overall the weight of bruised trim from fed bullocks (0.48 kg) was less than that from bullocks starved for 24 h (0.99) or 48 h (1.03 kg). Overall, duration of feed withdrawal had no significant effect (Dodt, et al. 1979).
Shipping fever is the most important disease associated with the transport of cattle and has caused severe economic losses, particularly in Canada and in the USA. It has also been reported in most European countries (Hails, 1978). It occurs mainly in store cattle fatigued after long transport with insufficient feed (Thornton and Gracey, 1974) although it can occur in calves (Barrett and Neylon, 1971). The syndrome is characterised by fever, dyspnea and pneumonia. The disease is initiated by lowered host resistance, as a result of exposure to stressors during transportation (Irwin, 1979). Typical stressors which were found to alter the immune system of animals include heat, cold, crowding, mixing, noise and restraint (Kelly, 1980; Tarrant, 1982).

4.1.3. Mortality and injuries in pigs

In the Netherlands (Van Logtestijn et al., 1982) the overall transport death rate, including lairage, decreased from .42% in 1972 to .3% in 1980. The number of deaths in the lairage was on average .07% in 1972 and .05% in 1980. It is well known that transport losses are much higher during the summer months than in the winter months due to higher temperature and humidity. Transport losses are also caused by rough, abusive and otherwise inconsiderate treatment of pigs by handlers and transport personnel. The death rate of pigs, transported for 2 or 3 days over long distances (about 2500 km) was only 0.17% (Marov,1981). However the possibility that pigs suffered from severe stress to such an extent that their meat quality was decreased was not investigated. During transport by road of 2,000 pigs from the Netherlands to Italy the death rate amounted to only .1% (Lambooy, 1982). Similarly, in the UK between 0.5% and 0.12% of pigs taken to slaughter die en route or in lairage.

A Swedish investigation (Fabiansson, et al.1979) showed that the death rate during transport to and lairage at 25 abattoirs was 0.13%. These losses remained static over several years. The financial losses due to deaths amounted to about three million Swedish crowns per year. In Germany the death rate during transport increased from 1962 (0.24%) to 1975 (1.0%) (GRATL, 1981). Since then losses remained constant at 1%. The authors calculated the financial losses for 1980 to be 102 million DM per year (1% of a total of 34.8 million slaughter pigs at an average price of 300 DM per slaughter pig).

According to Nielsen (1982) transport losses were reduced when lorry and lairage were fitted with ventilation, in which case losses amounted to 0.24 per thousand in transport and 0.68 per thousand in lairage compared to 0.46 and 1.06 respectively without ventilation.

Contrary to the European results, Clark (1979) reported that transport losses of slaughter pigs increased recently in Saskatchewan. The losses increased from 2 per thousand in 1974 to a high of 4 per thousand in 1978. The highest losses occurred at the hottest (July-August) and coldest (December-January) months of the year. Seventy per cent of the deaths happened in transit, the remainder occurred at the abattoir before slaughter. The pigs were transported in trucks for an average distance of 150 km (15-450 km).

The Meat and Livestock Commission (UK) found in a survey of 10,000 pigs that over 50% of all carcasses were damaged. The carcasses of 44.4% of all pigs surveyed were damaged particularly around the head and shoulders by fighting. Fourteen pigs were dead on arrival at the factory, of these 8 were badly damaged by fighting. Bruising occurred in 7.9% of all carcasses. Bruising was not confined to any specific part of the body although it was more common in the central pelvic area. The causes included striking with sticks, kicking, crowding in gateways, trampling at loading, unsatisfactory vehicle or lairage floors and the misuse of slap markers. Visual inspection did not always show the full extent of the damage. Some surface discolourations which appeared to be of little importance were found on cutting to conceal serious bruising necessitating condemnation. Skin blemishes or discolouration occurred in 3.6% of the carcasses. These seldom penetrated into the underlying tissue but were of importance where carcasses or rind-on-joints were sold. Blemishes were caused by urine scald, a consequence of inadequate bedding on long journeys or of holding pigs for long periods in lairages without bedding and with inadequate drainage.

4.1.4. Mortality and injuries in sheep

There are few reports in the literature of sheep losses during road transport. Heat stroke was found as the main cause of mortality in sheep transported by sea from Australia to Singapore, and in shipments from Brazil to Iran. Mortality rates on these transports were 0.3 to 1.7% for 8 to 9-day voyages and 3.6% for 18 to 20-day voyages (Gardiner and Craig, 1970); Mondino Silva, 1973). Other causes of mortality were Salmonella infection and hypocalcaemia (Hails, 1978).

Geyer (1982) reported very low mortality in transit. In 1980 there were 14 deaths among 234,434 sheep transported by road. There are some reports of much higher road losses. In the summer of 1982, German police stopped a truck transporting sheep from Poland to France at Baden where the Polish-speaking driver had lost his way. Veterinary authorities found many animals dead and others in such poor conditions that they ordered immediate slaughtering. The total losses were 65 out of 400 transported sheep (Pevec, 1982).

The Meat and Livestock Commission of the UK (1974) reported bruising damages in 10% of all fat lambs and hoggets. According to this study the fat lamb and sheep industry has an annual output of £ 120 (stg) to £ 140 million. If 10% of these animals marketed are reduced in value by 2p/lb carcass weight, the total loss will amount to about £ 1.0 million. The report found three main categories of damages. Bruising was most severe in milk-fed lambs and was evident over the shoulder, in the area of the ribs, on the loin, the rump and down the hind leg. Damage appeared to be worse in lighter weight lambs. Bruising of weaned lambs and hoggets was seen mainly along the back and on the rump. The cause of a particular bruise was difficult to pinpoint, but stick marks wool pulling, crowding in gateways and trampling by other lambs during drawing, loading or in transit, all contributed. Bruises may also be caused by rough handling when ear tagging prior to loading, or subsequently during the process of loading or unloading.

Poor vaccination techniques can result in secondary abscesses, causing severe damage. Blood splash (blood spots or streaks in various parts of the lean meat) may assume serious proportions in certain conditions.

4.1.5. Mortality and injuries in poultry

Losses during transport of broiler fowl in Germany in January - March, April - May, and June - July were 0.22, 0.18 and 0.23%, respectively, while in old hens losses for the same periods were 0.16, 0.17 and 0.53% respectively (Hails, 1978). Seligmann and Lapinsky (1970) found mortalities of 0.32% in 28,704 slaughter poultry and of 0.64% in 19,195 birds delayed at a wholesaler for 2 - 3 days with no feed and water. Loliger and Torges (1977) found that transport-related deaths in one day old chicks are nowadays very rare, if transport does not last longer than 60 h and the ambient temperature is at least 25°C and not too high. Chicks normally travel well if ventilation is adequate, (King, 1970).

Hoogerbrugge and Ormel (1982) investigated the effect of temperature on one day old chicks transported in boxes by air. They found that when the temperature is over 34°C and ventilation is limited the temperature inside the box will increase rapidly to values exceeding 40°C. There is a strong correlation between body temperature and the higher temperature inside the box. When the body temperature rises above 40°C the activity of the chickens rises, further increasing heat production, and the chicks start panting. When the body temperature reaches values of about 43 to 44°C chicks become comatose and die very quickly. According to Loliger and Torges (1977) the death rate is between 0.02 and 0.4% in broilers and between 0 and 2.5% in spent hens. The losses are higher in summer than in winter.

The reasons for higher transport losses in laying hens compared to broilers were longer transportation times and higher susceptibility to transport stress. The same authors found a death rate of 0.59% in turkeys. Most losses were caused by chronic pericarditis, epicarditis, liver cirrhosis and intestinal diseases. However, injuries attributable to the method of loading were rare. Scholtyssek and Ehinger (1976) examined broilers after 2, 4 and 6 h journeys and found more bruising after longer transport times and in transport cages with more space.

Unsuitable transport vehicles, prolonged waiting times, and rough handling contribute to an increased death rate in farm animals.

4.2. Influence of transportation on carcase weight

4.2.1. Weight losses

The reduction of live weight and carcass weight during transport is of major concern to the livestock and meat industries (Tarrant, 1982). Loss of live weight results from excretion, evaporation and respiratory exchange (Dantzer, 1982). Loss of carcass weight during prolonged transportation is due to the dehydration of the carcass tissues and to mobilization of depot fat and muscle glycogen. Tissue protein catabolism may also occur, due to glucocorticoid action (Trenkle, 1981). Loss of weight due to tissue breakdown in fasted animals will occur earlier in monogastric animals than in ruminants (Tarrant, 1982).

4.2.2. Weight losses in cattle

Shorthose (1965) calculated that the approximate rate of carcass weight loss in steers was 0.75% per day for transport and holding times lasting from 3 to 8 days. Liveweight losses in cattle were about 8% for the first 24 h of transport, considerably in excess of the loss expected from fasting alone. During the next two days liveweight fell about 2% per day. Mayes et al (1979) found that slaughter cattle handled and transported a distance of 85 km in

5 h shrank by 2% of liveweight. Those handled and transported 1,250 to 1,625 km during a 26 h period shrank by 6.3%.

The long distance journey described by Friend et al (1981) referred to previously in this report, resulted in weight losses of 10.6% in calves transported by truck. The rail shipment had a lower weight loss than the truck shipment (4.1% during the truck transport to the train, and 2.1% during rail transport and truck ride to the destination). The calves transported by rail had a significantly higher average daily gain at 7 and 14 days post transit, but there was no difference between the road and rail transports after 28 days. The effects of dehydration after a long journey (1,420 km) by road and rail on liveweight, carcass weight and muscle properties of cattle were examined by Wythes (1980). After unloading, bullocks were watered without feed for 0, 3.5, 7, 28 or 32 h or watered with feed for 32 h, prior to a 16 h preslaughter fast. This treatment allowed 108 bullocks in the first three treatments (36 animals per treatment) to be slaughtered after resting for one day and the remaining 108 after resting for two days. Bullocks lost 10.4% of initial liveweight (656 kg) in transit. The mean liveweight of 588 kg on arrival increased when the animals had access to water, so that after 3.5 h on water the net liveweight loss was reduced (P 0.05) to 6.0% of the initial liveweight. After longer periods the loss varied from 6.8 to 7.3%. The net loss of the group also offered lucerne hay was 6.7%. In another study cattle lost up to 13.5% of initial liveweight during long distance transport to abattoirs in northern Australia (Wythes, unpublished data).

Losses of body weight are reported to be the most significant economic effect of transport, Leach (1982). Self and Gay (1972) monitored liveweight changes in 4,685 feeder cattle, weighing between 255 and 275 kg, transported by road over distances between 240 and 1,824 km (average 1,023 km) in the USA. Cattle collected directly from ranches showed an average loss of 7.2% body weight, while those collected from auction markets averaged a 9.1% loss (P 0.05). Weight loss increased by 0.38% for every 100 km of the journey. Weight losses are influenced by the seasons, they are greater in summer months than in cooler periods.

4.2.3. Weight losses in pigs

Live weight losses are high initially; about 0.5 to 1% of live weight is lost per hour of transport in piglets. Of live weight lost during trucking for 2 h 42% was accounted for by excretory products, while 58% was attributed to evaporative loss and respiratory exchange. Of the latter data 36% was attributed to road travel and 22% to the stress of handling and confinement. Live weight loss - when corrected for excretory losses - was correlated to ambient temperature and humidity, and increased with duration of transport or social grouping (Dantzer, 1982).

The weight loss during transport for 2.5 to 3 days was 10.2% on average (Markov, 1981). In transports from Holland to Italy by road 5.2% was the average liveweight loss for 6 transports totalling 1,200 pigs (Lambooy, 1982). Actual losses depend largely on climatic conditions. These losses are considerable and enforce the suspicion that long lasting transports mean a lot of suffering for the transported pigs. Weight losses are caused by excretion and by depletion of the reserves of bodyfat during lengthy fasts. This situation has not necessarily a detrimental effect on their health (Van den Bergh, 1977). The influence of preslaughter fasting on carcass and liver yield in pigs was examined by Warriss and Brown (1983). They found that live weight began to be lost by pigs almost immediately after food withdrawal. Loss of carcass weight started after between 9 and 18 h. Although no difference was found in the composition of chops from animals fasted for different lengths of time there was evidence that some of the carcass weight loss was attributable to loss of water. Liver weight decreased rapidly over the first 24 h after food withdrawal and a large part, but not all, of this decrease was loss of water and glycogen. The rates of loss between 18 and 48 h of fast were 0.21% of live weight and 0.11% of carcass weight per hour.

Results suggest that the effects of transport are independent of, and additional to, those of fasting (Warris et al 1983). Significant losses in carcass yield can be attributed to transport even in pigs which have been fed before transport. Fed pigs lost on average 1 kg of liveweight in the first hour of road transport and an additional 0.4 kg per hour in journeys lasting for 6 h. The 1 kg live weight lost during 1 h transport is mainly due to loss of gut contents and urine. On the other hand, carcass weight was significantly reduced in a 6 h transport group, by about 1 kg of carcass weight.

4.2.4. Weight losses in sheep

Lambs of 40 kg liveweight starved for 18 h, then transported for 1.5 h lost 0.9 kg (Rudloff, 1974). Sheep will lose up to 3.6 kg during transport for 24 h, but this is mainly loss of ingesta, as tissue loss appears to be only slight during journeys of this length, (Thornton and Gracey, 1974). However, during prolonged transport by rail (more than 3 days) in South Africa, it was shown that significant losses in carcass yield can occur (Sutton and van den Heever, 1968). In lambs, loss of carcass weight was nearly a linear function of fasting time and occurred at a rate of about 1.5% of initial carcass weight per day for up to four days of fasting (Starke, 1948 cited by Shorthose, 1965). A series of New Zealand lamb experiments has indicated that carcass weight reduction resulting from pre-slaughter starvation is a source of loss to the meat industry. Carcass losses start between 8 and 24 h off pasture and a loss of about 0.25 kg by 24 h has been noted (Kirton et al., 1972).

The Meat and Livestock Commission, UK,(1974) reported the influence of distance from farm to slaughterhouse on liveweight and carcass weight. Milk lambs and weaned lambs (totalling 1,100) were transported between 9 and 160 km (average 66 km). The milk lambs were slaughtered within 3 and 6 h of loading, the weaned lambs were held over night and slaughtered within 22 - 26 h of loading. The findings indicated a small increase in live weight loss with increasing distance. Killing out percentage based on farm liveweights were higher where liveweight losses in transit were low.

4.2.5. Weight losses in poultry

Broilers transported for 1.5, 3 and 4.5 h had weight losses of 1.3, 2.3 and 3.1% respectively (Scholtyssek et al 1977). In another study Scholtysser and Ehinger (1976) reported significant differences in weight losses in broilers were observed in some trials after journeys of 2, 4 and 6 h. Blood corticosterone concentration and creatine kinease activity, indicating tissue damage, reached their highest values after 4 h of transport.

4.3. Influence of transport on meat quality

In addition to the problems of bruising and loss of carcass weight discussed in the previous two sections, transportation of meat animals to slaughter may adversely affect meat quality. The two most common stress-related meat quality defects are pale, soft, exudative (PSE) and dark-cutting or dark, firm, dry (DFD) meat. PSE meat is of normal acidity and keeping quality, but is abnormally pale and watery and gives lower yields in cooked and processed products. DFD meat is of low acidity, poor keeping quality, dark in colour, and has a high water-binding capacity. Abnormally low pH values in the hot carcass (pH_1 values below 6.0) are associated with PSE meat, whereas high final or ultimate pH values (pH_u values above 6.0) indicate DFD meat.

4.3.1. Meat Quality in Cattle

According to Leach (1982) the most common defect in beef attributable to transport is probably dark-cutting, in which *in vivo* depletion of the glycogen reserves of the muscles results in failure of the pH to fall to normal levels post mortem. Prolonged stress, emotional as well as physical, which may result from mixing strange animals, e.g. in overnight lairing, withholding food and water or exposure to marked diurnal temperature variations. Substantial losses of muscle glycogen preslaughter result in dark-cutting meat. Tarrant and Sherington (1980) observed that dark-cutting in beef may be caused by hardship arising from higher meat factory throughput of (grass fed) cattle in the autumn. When throughput is particularly high, stress is likely to result from delays in transport and increased mixing of cattle during the preslaughter periods. They observed a seasonal effect with more dark-cutters in the period September to January (5.2%) than from February to August (1.2%). The degree and duration of excitement and anxiety have a major effect upon the incidence of dark-cutting (Hedriek, 1981). Dark cutting beef was induced by the indiscriminate use of an electrical goad such as the "hot-shot". Short-term mistreatment (2h) did not produce dark-cutting, but longterm mistreatment did. Young bulls are particularly susceptible to the DFD condition because of higher levels of aggressive and sexual activity among male animals (Tarrant, 1982). There is a period of intense behavioural stress after mixing while a dominance hierarchy is being established. The reaction of steers to social regrouping is less energetic.

Shorthose et al (1972) studied the effects of a long journey of 400 Shorthorn steers transported 322 km by road to a railhead. The animals were rested for 16 h, with water available, and then railed 966 km to the meatworks, a journey which took a further 42 h. Steers rested and fed for 4 days rather than 2 days after the long journey to slaughter had a lower pH in *M. longissimus dorsi and flexor profundus* 24 h post mortem and a lower 48 h pH in M vastus lateralis. It was possible that muscular activity during the journey depleted the glycogen concentration of the leg muscle (M vastus lateralis) more than in M longissimus dorsi. It was of commercial interest that the extra holding period reduced the proportion of animals with a 24 h pH value above 5.8 in M longissimus dorsi. The extra holding period before slaughter did not significantly affect the mechanical properties of the cooked leg or loin muscles or the percentage loss of weight during cooking.

Cervenka (1968) found, that with increasing distance and duration of transport the pH of the meat increased but little in cattle transported by rail. Fischer and Augustini (1980) studied the effect of different transport temperatures and food deprivation for several days. Holstein-Friesian bulls were transported for 4 h in an air conditioned truck at 2, 12 or 36° C and 65% relative humidity and were slaughtered immediately afterwards. Temperature had no effect on heart rate, but at 36°C ambient temperature the rectal temperature was significantly raised during transport. Measurements taken at 45 min and 48 h post mortem showed a tendency towards lower glycogen and higher lactate and glucose contents, particularly in M semitendinosus and M semimembranosus. Final pH and water binding capacity were not influenced by this treatment. In bulls transported under the same conditions but then penned without feed for 48 h before slaughter, muscle glycogen decreased by 50% and half the animals had final pH values higher than 6.2 in M longissimus dorsi. Final pH values and water-binding capacity values in other muscles also differed significantly between starved and non-starved animals.

Cervenca (1971) reported that the meat pH was only marginally higher in slaughter cattle transported at higher ambient temperature (30 - 34°C) than in cattle transported in a cold season (0 to 4°C). Resting bullocks after a long journey of 1,420 km for two days rather than one day significantly reduced the pH values of the M longissimus dorsi at 24 h post mortem from 5.64 to 5.57 (Wythes et al, 1980).

Tarrant (1981) concluded from questionnaires he circulated that preslaughter stress was the most frequently cited cause of dark-cutting in beef. Problems were associated with inadequate handling, transport and penning of cattle. Problems with transport were specified as overlong distances or times in transit, bad conditions during transport and insufficient recovery time after transport. Also climate was seen as an important factor causing dark-cutting in beef. The specific climatic features mentioned were inclement weather, large daily temperature fluctuations and excessively hot or cold environmental temperatures.

4.3.2. Meat quality in pigs

In pigs, as in cattle, there is ample evidence that stress and exhaustion occur during preslaughter transport and handling. Clark (1973) showed that lower meat quality (DFD) and lower yield of liver resulted from long distance transport of pigs by road in Britain. The average distance travelled by pigs to a bacon factory was 193 km. Pigs then fed sugar in solution to replenish lost stores of liver and muscle glycogen, gave better meat quality (lower ultimate pH values) and better yields of liver. Gallwey, Tarrant and McMahon (1977) studied carcass yield and meat quality in pigs after road transportation of 80 km and overnight lairage at a bacon factory. Their results supported those of Clark (1973). They observed that sugar-feeding (2.2 kg of syrup) of pigs after transport lowered the ultimate pH of the meat, improved the keeping quality of the cured meat, gave a higher carcass yield and a substantial increase in liver weight compared to control pigs that were held overnight after transport, with access to water only.

The ultimate pH of 34% of the muscles of the control group were abnormally high (above 6.0) compared with 8% in the sugar-fed group. The hot carcass weight of sugar-fed pigs was significantly greater than that of the controls, and the carcass yield was significantly higher for the sugar-fed pigs (77%) than for the controls (73.7%). Sugar feeding produced an increase of 34% in cold liver weight. The added weight consisted almost entirely of carbohydrate and moisture.

Gallwey and Tarrant (1978) showed that there is a relatively high incidence of pigmeat of abnormally high ultimate pH value (DFD) in the Irish bacon industry. The source of pigs, factory, time of year and grade had significant effects on ultimate pH value of pork. However, over 80% of total variation in the ultimate pH of pork remained unexplained by the general variables mentioned and was considered to be due to specific environmental stressors acting on individual pigs during the preslaughter period; transport being only a part of it.
Pigs from small fattening units had the lowest pH_u values, pigs from large fattening units had intermediate values and pigs brought at market and from dealers had the highest values. This was considered to be due to better preslaughter handling and transport of pigs from small units. They were usually delivered by the owner to a local factory in small unmixed groups. The higher values of pigs from large fattening units were probably caused by a combination of factors contributing to increased stress, such as mishandling during loading and unloading, inadequate transport type, fighting among pigs from different pens and possible adverse physiological effects of intensive husbandry practices. In addition to the above stress factors pigs purchased from dealers and markets (which had the highest pH_u values) frequently suffered from exposure, low nutritional status, travel fatigue and the effects of interaction between groups collected from different sources.

DFD meat is also a common problem in the British pigmeat industry as can be seen from the data of Kempster and Cuthbertson (1975) and Chadwick and Kempster (1983). Exhaustion of pigs during preslaughter road transportation and penning at the factories is a widespread problem with serious economic implications for the pigmeat industry and negative welfare implications also. In the Netherlands it was estimated that up to 15% of all slaughter pigs suffer from being transported to such a degree that their physiology before slaughter and their meat quality afterwards are definitely abnormal (van Logtestijn, 1970).

Post mortem muscle metabolism determines the occurrence of PSE and DFD properties, and these were also recorded on the basis of the chemico-physical properties of the meat. It was found that there was an extraordinarily high proportion of PSE meat in all conditions of transport studied (about 53% in M longissimus dorsi and about 31% in M semimembranosus). No definite differences in pH value, colour brightness, water-binding capacity and state of rigor were observed between the variants.

It is evident that even very careful transportation cannot prevent poor quality in the meat if the animal is constitutionally disposed in that direction. The results emphasise the need for very good ventilation, particularly on sultry days, and a reasonable stock density. These measures will be unavailing however, unless the constitution of the modern pig can be improved by breeding.

In a subsequent experiment with halothane tested pigs it was shown that under uniform transport conditions the significant differences in PSE occurrence between animals were explained almost exclusively by halothane reaction, Augustini and Fischer (1982). A further reason for the difference within treatments was due to differing degrees of muscling. This supports the opinion that the incidence of PSE meat determined more by genetic factors than by preslaughter treatment. It is important to standardise the method of judgement of meat quality. Von Mickwitz (1982) found that at routine meat inspection, of 237,058 slaughtered pigs only 99 (0.41%) were classified as PSE, but when measured the carcass pH at 45 min post mortem (at the same slaughterhouse) the frequency of PSE-type carcasses based on low pH_1 values increased to 20.6% (239 of 1160 carcasses examined).

According to Nielsen (1982) the longer and more stressful the preslaughter treatment is for the pigs the more pigs have DFD meat and the fewer pigs have PSE meat. The author reports an experiment in which 84 pigs were taken 20 m to the stunning pen without any kind of force being used while the same number of pigs were normally transported and held in lairage. The results showed that the extremely considerate treatment on the day of slaughter led to a higher incidence of PSE meat, but no DFD occurred. Activity during transport and lairage ensured a certain amount of muscle energy (glycogen) consumption and thus fewer pigs with PSE meat.

Prange et al (1977) transported (60 to 70 min) a total of 1,010 slaughter pigs either by truck conventionally or in containers each of which contained 7 pigs of one fattening group. The method of transportation did not influence the pH-value, colour brightness and drip loss of the pork. Transport losses were reduced when the animals were transported in containers due to less voluntary muscular activity. However, because the treatment of the animals was the same after arrival at the slaughterhouse, the advantage of containerized transport may be lost and no benefit achieved in terms of meat quality.

4.3.3. Meat quality in lambs

The effect of transport and physical stress on ultimate pH of lambs were studied by Chrystall et al (1982). In the first part of the experiment, transport (400 km, 9.5 h) and light exercise (2 km walking) were shown to have very little effect on mean ultimate pH values of M longissimus dorsi but there was an increase in inter-animal variability in pH_u values. In the second stage, recovery from severe stress was followed by serial slaughter of groups of animals. Ultimate pH values were still slightly elevated above normal after 24 h of recovery. The inter-animal variability in pH_u in the stressed groups was very high with some animals being relatively insensitive to stress and others recovering very rapidly.

4.3.4. Meat quality in poultry

Scholtyssek et al (1977) investigated the influence of transportation and starvation on the carcass quality of broilers. They only found significant physiological effect of stress or exhaustion after starvation for longer than 12 h. The carcass quality showed little affect, only the tenderness was reduced, when the birds were starved for longer than 12 h.

Ristic and Schön (1977) studied the effect of transport distances of 10 - 15, 36 and 90 km in broilers. The water-binding capacity of water-cooled carcasses was better after 36 km than after either of the other two distances studied.

Ehinger and Gschwindt (1979) investigated the effect of transport times between 0 and 6 h on meat quality. They found that water binding capacity and loosely bound water were worst after 4 and 3 h of transport, respectively. Meat tenderness was lowest after 4 h. They also found that by increasing waiting periods the tenderness of the breast and thigh meat decreased. The water-binding capacity also decreased. Female birds had greater roasting losses from both breast and thigh meat and higher pH in the thigh than male birds. The pH at 15 and 45 min post slaughter was 5.87 and 5.74 respectively in non-transported birds, 6.3 and 6.18 in birds transported for one hour, and 6.1 after six hours of transport. Ehinger and Geschwindt (1981) studied the influence of transportation for 2, 4 and 6 h on meat quality and on physiological parameters, in 240 birds of four commercial strains (Lohmann, Hybro, Hubbard, Ross). Water-holding capacity of raw breast meat, tenderness and cooking losses in thigh and breast meat were not substantially influenced by transport and strain, but female birds showed inferior results with these characteristics. pH_{15} was lowered significantly after 4 and 6 h of transportation in breast and thigh meat. Scholtyssek and Ehinger (1976) examined criteria of meat quality in broilers after journeys of 2, 4 and 6 h and found negative effects on the shear force values after the longer transport times.

<u>Much work has been carried out on liveweight loss and loss in carcase yield following transport. Both occur but vary considerably with different species, transport methods and practices. Similar work has been carried out on meat quality with similar findings.</u>

5. <u>Conclusions and recommendations for further research and development</u>

1. It is obvious that transportation is a critical period for the animal but the effects of transport can be alleviated by good conditions and handling. There is also much evidence that careful handling reduces bruising to livestock and thus to the carcase and that most of such damage occurs at loading and unloading if the facilities for those procedures and the way in which they are carried out are unsatisfactory. As generalisation, consideration of all the available and relevant scientific information contained in the previous pages, both experimental and that obtained by observation under normal working conditions, indicates that attention to the preparation of livestock prior to transport, improved loading and unloading facilities at the beginning and end of transport, improved handling and physical transport conditions would all result in improved animal welfare during transport of livestock to slaughter.

2. It is obvious that animals will tire during transport and they may be seen to rest in preference to eating after a long journey. However, other stressors can still occur on short journeys and conclusions on the merits and de-merits of long as against short journeys cannot be drawn with any certainty.

3. To enable a valid conclusion to be reached on the question posed at the beginning of this study more information is required on, amongst other matters, the interpretation of the various physiological measurements which can be made on livestock during transport; which of those measurements are most useful with regard to deciding on criteria which will indicate the onset of

distress and the relationship of those physiological measurements with a time limit to be set for any journey, and in particular the final journey of livestock to the slaughterhouse.

4. Despite the great deal of available knowledge which if used would enable animals to be transported, according to their species, age and condition with little stress, there are many areas where it is impossible to make specific recommendations on transport conditions because vital information is lacking. The appropriate time prior to a journey, during a journey, and after a journey at which feeding and watering by species, age and physiological condition is administered is not precisely known. There are great differences between the monogastric species and the ruminant and there will be considerable differences in their requirements at different times of the year. Stocking densities by species, age, physiological condition and method of transport are based very much on practical observations but there is still much more information required, which could be obtained by observational studies, before advice on stocking densities that provide for all species and all methods of transport can be promulgated. In addition the ventilation requirements of the various methods of transport are not precisely known for all species, age and physiological condition of animals; and the effect of lack of rest for all livestock is an area in which very little, if any, work has been carried out.

5. At the present time with the vast majority of transport methods, limiting factors for journey time will depend on:

(1) The species (whether ruminant or monogastric) age and physiological condition (pregnant or not pregnant, shorn or unshorn in the case of sheep etc.)

(2) climatic conditions during the journey

(3) the construction and ventilation of the means of transport

(4) methods of loading and unloading

(5) methods of preparation of livestock prior to the journey

(6) methods of reception of livestock at the end of the journey.

6. The range of combinations of all these factors is almost infinite and except in a very few instances it is impossible to draw conclusions on journey time. On a very hot day, with fat pigs, poor preparation, with poor loading facilities and a poor means of transport, all lead to the conclusion that the journey time must be as short as possible (indeed a journey in such conditions may not even be indicated) whereas on the other hand with good preparation, good means of transport, with adequate room, ventilation, and watering and feeding facilities on board, it could be argued that a journey of indefinite length is possible without distressing the livestock so carried.

7. So more information is required before definitive conclusions can be reached on what limit should be placed on the duration of the transport of livestock being conveyed to slaughter. However, it still may not be possible to reach such conclusions even after further investigation. Further research is certainly required into:

(1) when and how to feed and water animals prior to and during transport by age, species and physiological conditions

(2) the importance of rest during transport and by what means animals can be provided with environments during transport in which they can rest, or is there a need for journeys to be broken for the provision of rest

(3) stocking densities by species, age, sex and physiological condition;

(4) ventilation requirements of the different modes of transport for the different species;

(5) the economic effects of the various methods of transportation on the quality of the meat produced;

(6) information on morbidity and mortality during transport by species, age and physiological condition;

(7) investigation of the design of lairages at slaughterhouses and the provision of water and feed (or not) prior to slaughter;

(8) further investigation of the various physiological measurements which can be used for assessment of changes in the physiological and psychological status of livestock and the significance of those measurements in relation to assessment of any time limit which should be placed upon the journey of livestock being moved to slaughterhouses.

8. There would appear to be two main methods by which this further research can be carried out and both require the closest possible co-operation between Member States of the European Communities.

(1) Observational studies of transported livestock in intra-Community trade

(2) Laboratory investigations using the expertise and facilities which exist within the Community on a co-ordinated basis, to encourage the exchange of information in small seminars and workshops; by the exchange of research workers; and the funding of specific research contracts.

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Appendix 1

7. References

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Appendix 2

8. An examination of transport according to the behaviour of different species

The main purpose of this report is to examine questions of transport. However since this section, the main and salient points of which are in the text, exists dealing with species it seemed useful also to present this information as an appendix to the text.

There are obvious differences both within and between species in their physiological and behavioural reactions to transport methods and practices.

1. Horses in transport

The few reports of horses destined for slaughter in international long lasting transports are that of Bornkessel (1982) and Geyer (1982). Both authors describe transportation of horses from Poland or Soviet Union to France, Belgium or the Netherlands via Germany. Bornkessel (1982) gives a description of a rail transport. If the horses are found to be fit for transport by Polish veterinarians, they are fed and watered before loading, also the shoes have to be removed. The horses are tethered in a way that allows them to take hay from the floor and lie down. They are separated from any neighbour by beams.

From 1973 to 1979 most transport of horses was done by train. But since then the transports changed to the road, so that in 1980 only 9000 (25%) horses were transported by train, but 27000 horses were carried by road. The transport of horses by road is criticized by Weichert (1981). Heholds the opinion that transport by road is more adversive to horses than rail transport and that the inspections at the border are not done intensively enough. Little information about the physiological response to transport in horses is known. The most frequent causes of death or serious sickness were chronic diseases of the legs and respiratory organs, and disorders of the heart and circulatory system, while injuries were found on the legs and bite injuries on the head and neck areas.

2. Cattle in transport

Kenny and Tarrant (1981) gave a review of the behaviour of cattle during transport and penning before slaughter. The following is an extract of this paper. The authors divided behaviour during transport in four stages: behaviour after loading, standing in transit, lying down in transit, and behaviour in stationary wagons.
Bisschop (1961), one of the cited authors, found two different sets of behaviour occurring in the interval between loading and departure. In one case, where the interval lasted 1.5 h the steers (of mixed breeds) were very nervous and restless, showed trembling and kept on butting each other and changing their positions in the trucks. They defaecated and urinated copiously. This state lasted for the first 4 h after departure. During the following 8.5 h the animals settled down; they stood resting. In two other studies of the same author (one consisted of cattle of mixed breeds and the other of Afrikanertype cattle), 3 h elapsed between loading and departure. No animals showed nervousness, trembling or more than normal elimination. They did, however, mill about. The author offers no explanation for this difference. However, the first group travelled 8 h to the railroad station and seemed to spend just one night there. The other groups travelled 2.5 days and 5.5 days to the railroad station, respectively. It is possible that the first group had not sufficient time to complete formation of a social hierarchy. Sutton (1968), another cited author, noted the behaviour after loading of Afrikaner-type oxen from a single herd. Initially they were restless and anxious. A high state of alertness was suggested. This stage of unsettled behaviour lasted only 30 min, probably due to the established nature of the group. According to the mentioned authors, groups of cattle tend to settle down soon after departure, although occasional groups exhibit continued nervousness as described above. While they are in motion, animals stand parallel to each other and at right angles to the direction of travel of the train, facing indiscriminately in either direction. This position appeared to be the best to counteract the sideways sway of the truck when it was moving.

An animal rarely changes its position while the train is moving, once the parallel pattern across the railway truck has been formed. Cattle often lie down in the trucks while they are moving. In a 9.5 h journey by road, Anderson (1973) found 25 animals out of a total of 494 down. Of these 20 were lying in a normal position and were easily brought to their feet. In rail travel the animals usually do not lie down until 20 h after the journey has started. When they were unloaded in rest periods, they remained standing for 13-17 h after reloading, before the first one lay down. In the course of a 96 h journey without off-loading all the cattle lay down at one point or another (Sutton, 1967). Up to 13 h travelling after the first rest period it was easy to force bullocks to their feet. From this journey time on, more animals were found down and were assisted to their feet with increasing difficulty. After 31 h travelling some 50% of the heavier and 25% of the lighter bullocks were down in the wagons. The period spent lying down averaged 15 min, but could be up to 5 h at a time. A greater percentage of animals lay down in the padded than in the unpadded wagons. Standing animals continued to maintain the parallel pattern across the truck, although occasionally the animals nearest the one lying down stood lengthwise in the truck with their heads over it. Standing animals were careful not to trample on recumbant ones. However, another author found that the animal with the heavier bruise trim weight was down in the truck during the journey. Tramping would be unlikely if the animals were calm or not thrown off balance. In transport by road the animals became unsettled when the vehicle was stationary. During rail transport the standing position was rarely changed until the train came to a halt. The animals frequently moved to face the direction while the train was moving or to haphazard positions. However, the transverse position was immediately re-assumed when the train started to move.
Friend et al. (1981) reported on a long journey of about 2000 km by rail and road. As mentioned before 150 Angus X Hereford steer and heifer calves weighing about 165 kg were transported from Tennessee to Texas. 50 of these calves were loaded into a conventional cattle truck and transported directly to the destination point. The other calves were transported by truck 750 km where they were trans-

ferred to the railcar. After loading the calves immediately commenced eating hay and drinking water, reflecting the water deprivation during transport to the railcar. The calves remained highly active for the first two hours after loading. After 2.5 h after loading two-thirds of the animals on the bottom deck were lying down. None were lying down on the upper deck, but these were disturbed several times by personnel checking equipment.
Many of the cattle were lying down while the train was standing (-25% of the time in transit) or moving at slow speed (30 km/h or less). Lying while the car was moving was a common occurrance from midnight (6 h after loading) of the first day on. If the ride was rough, almost all would stand. Those that remained lying were usually along a wall. Examinations of videotapes showed that the calves positioned themselves in a random manner throughout the car regardless of speed and smoothness of ride. The calves continued to eat hay and drink regardless of the smoothness of the ride. When the car was standing still, consumption was greatly reduced as calves lay down to rest. When the car started moving, the calves stood up and commenced eating and drinking. Apparent hay (5.1 kg) and water 21 l) consumption per head was normal.
The calves showed no heat stress despite the presence of only a slight breeze. The combined transport by truck and railcar lasted 69.2 h and the transport by truck 36 h.

Shorthose et al. (1972) described a transport of cattle in Australia, where cattle are transported often long distances to slaughter. In this case a group of 400 Shorthorn steers was transported 322 km by road to a railroad station. The animals were rested for 16 h, with water available and then railed 966 km to the meatwork, a journey which took a further 42 h. The cattle had been without feed for approximately 4 days. After arrival, three groups of 20 animals were split from the group and put into a bare resting paddock. The remaining 340 animals were held together, in another bare resting paddock. One group (no. 1) had access to water and another group (no. 2) to feed and water for one day after arrival and both groups were killed 2 days after arrival. Two groups (no. 3 and 4) were slaughtered 4 days after arrival. Group 3 had access to feed for 2 days and water for 3 days prior to slaughter and group 4 had access to both feed and water for 3 days. In the first 23.5 h in the holding paddock the apparent water consumption by the 60 steers in the groups 2, 3 and 4 was 25.9 l /head. 20 l /head was consumed in the first 5.5 h. From 23.5 to 50.5 h consumption by the 40 cattle of groups 3 and 4 was 11.4 l /head in the period 50.5 - 73.5 h after entering the holding paddock.

On the first day the apparent consumption of molassed hay was 0.66 kg/head, groups 2, 3 and 4. This increased to 0.86 kg/head on the second day, groups 3 and 4, and 0.92 kg/head on the third day, group 4.

Kenny and Tarrant (1982) in their review report about transportation of horned cattle, when animals are left undisturbed there is always more activity among groups of horned cattle than among dehorned cattle. Heterogenous groups were always midway between the horned and hornless groups in activity. On closer observation, most of the activity seemed to be of the avoidance type. No serious degree of malicious horning or aggressive behaviour was observed but many incidences of accidental horning and impedance of free movement were noted. Horned cattle find it hard to manoeuvre without brushing other stock in the crowded conditions and some horning can occur when new positions are being taken up. The incidence of bruising in horned groups transported by rail was observed to be 41.8% versus 20.1% in polled cattle. Other authors observed that there was a significantly higher amount of bruised tissue on the carcasses of horned cattle transported by truck to the slaughterhouse.
The long horns of Afrikaner type cattle in which the most observations have been made are especially likely to cause damages. But Kenny and Tarrant (1982) conclude generally that dehorning is an important requirement where cattle are transported in groups. Many animals are nowadays either polled or alrady dehorned as calves.

During a 24 h air journey, Hereford cattle browsed at hay but did not drink and for the most part appeared unconcerned during the whole flight. Resting behaviour seemed to be increased in the number of animals as the journey went on (Jackson, 1974).
Bailey et al. (1982) observed that in sea transport smaller cattle should not be kept with more than 40 head per pen even if large enough to carry more animals. In larger groups animals can get injured when they are caught against the fence while frightened animals all push in one direction. The authors recommend that groups of large size animals should not contain more than 20 animals for the safety of both the animals and their attendants.
The authors found that four-footed animals are generally more stable and show less stress than humans do during rough seas.

Von Hörsten (1979) observed that cattle kept on deck changed their ruminating behaviour. With increasing ambient temperature and duration of the journey they always started to ruminate sooner after eating. Also the time per ruminated bite shortened with the duration of the journey. It lasted 70-80 sec at the beginning of the journey and decreased to 50-60 sec.

In cattle kept below deck such changes could not be observed. The amount of consumed feed decreased with higher wind velocity in both cattle kept on deck and below deck. It also decreased in cattle on deck with ambient temperatures higher than 25°C. The feed intake of cattle below deck did not change since the temperature there was nearly constant. With increasing temperatures cattle on deck drank more water, e.g. with temperature of 18°C they drank between 24 and 28 kg water and at 28°C the consumption was between 32 and 38 kg per day.

Bailey et al. (1982) observed the behaviour of steers weighing about 630 kg during a sea transportation. Five animals were kept in modified 20 ft containers (standard shipping unit 8 x 8 x 20 ft, approximately one-half a truck trailer) equipped with a water bucket and a feed trough. From dusk to dusk (a 25 h period) animals were lying down

55% of the time, standing 30%, eating grain 7%, eating straw 5%, and drinking 3%. In light periods steers spent more time with the activities standing, eating and drinking and less time with lying down than in night periods.

3. Some physiological responses of cattle to transportation

Leach (1982) reports in a review of effects of transports on physiological systems: in 350 calves and steers, aged 13-14 months, transported 35 km to slaughter, loading caused high increases in cortisol, glucose, lipids, protein and urea, all indicating that the animals were stressed. Tissue protein catabolism may also occur, due to glucocorticoid (cortisol) action (Trenkle, 1981), which can result in decreasing tissue protein. Steers were more affected than calves. In animals then fasted 24 h before slaughter glycogen values were halved and 48 h fasting reduced them seven fold , compared with animals killed on arrival. In 1.5 - 2.5 year old heifers transported by road for 1.5 h and in 2.5 - 4.5 year old cows transported for 2 h cortisol levels and total white cell counts showed a marked increase over pre-transport values. The white cell count had returned to normal values within 10 h, while cortisol level was normal within 48 h.

Serum enzyme activity of calves, weighing 107 - 165 kg, transported by road 266 - 310 km, rose significantly; GOT increased by 7 - 38%, GPT 29 - 83%, LDH 14 - 42% and CPK 30 - 38%. The rate and degree of rise was greatest for CPK, but it also fell most rapidly.

In cattle serum values of GOT, LDH, and aldosterone (ALD) rose after transport and continued to increase to the time of slaughter, 20 - 50 h later. The rise in ALD was most marked and related to transport distance, age and ambient temperature. After long journeys pH was normal or slightly lowered, pCO_2 values were consistently decreased. Chloride levels were always raised and some groups showed a slight hypocalcaemia. In 18 - 30 month old Limousin cattle transported by road for over 500 km blood values of pCO_2 and pO_2 decreased while pH increased.

Transportation has been shown to result in a decreased plasma concentration of glucose and total proteins with a concomitant increased level of urea and uric acid (Agnes and Genchi, 1972). These authors suggested that such changes resulted from the muscular activity and starvation imposed by the journey. Stephens (1982) studied the effect of a road journey on kidney function in very young calves (usually under 1 week) intended for slaughter. From group of 14 such calves blood samples were taken for urea estimation at a market. Some degree of dehydration was observed as a consequence of scouring, while microscopic observations of the kidney in transport death calves showed signs of tissue degeneration. Subsequently the calves were loaded onto a standard cattle transporter capable of carrying up to 100 calves. After a 4-hours journey to the abattoir a second blood sample was taken immediately. The data for the blood urea levels were 50.2 mg/ml on the start and 59.1 mg/ml on the end of the journey. The difference was not significant.
According to Stephens (1982) in simulated transport studies there was small decrease of 5% in renal blood flow during the first few minutes of exposure. After a few minutes, the renal blood flow regained normal levels and than was elevated for the duration (45 min) of transport stimulation. Heart rate increased from 100 beats/min to over 140 beats/min and remained at this level for the duration of the transport stimulation.

Stephens (1982) investigated the effects of transportation on heart rate (HR) and plasma corticosteroid levels in calves aged 2 - 4 months. Calves standing and unfettered, HR was elevated from a resting level of about 80 beats/min (b.p.m.) to about 110 - 115 b.p.m. for 1 hour while the transporter was in motion.

Morisse et al. (1982) report some changes in blood components and biochemical parameters of 25 young calves stressed by transportation and starvation compared to 25 calves of the same age kept in optimal conditions at the farm of origin. Results show significant differences in stressed animals concerning: increase in thrombocytes and neutrophils counts, decrease in lymphocytes counts, increase in urea and serotonine (serum and total blood), increase in creatinine and 17 hydroxysteroids (urine), decrease in proteins, gamma-globulins and glycemia (serum).

The effect of transportation on blood serum composition was investigated by Mormede et al. (1981). Blood samples were taken before, during and after a 12 h transport by road with a stop at a transit centre. Transport induced increases in blood urea, creatinine, bilirubine, SGOT and LDH, suggestive of damages to kidney and liver. Energetic metabolites (glucose, triglycerides) were observed to decrease. Some degree of cellular damage was evident from the increased level of beta-glucuronidase. For most variables, the changes observed at the different stages of the transport were additive, a result which would suggest that they reflect more the effect of the transport duration than the consequences of the different components of the transport process. Trucking the calves produced an increase in cortisol levels which was maximum at the time of arrival in the transit centre. The cortisol levels returned to initial levels within one day. Plasma cortisol levels are of limited interest since the pituitary-adrenal axis habituates very rapidly (Dantzer, 1982).

4. Pigs in transport

To estimate strains of transportation Augustini and Fischer (1982) investigated the heartrate during transportation. For this purpose 77 barrows weighing 100 kg were transported singly for 14.5 min. The highest frequency rates were observed before and after transport. The values climbed steeply during driving to the weighing point, they dropped slightly while weighing and climbed even more during driving to the lorry. Within t he first minutes inside the lorry the heart rate dropped sharply. During transport the rate remained at a relatively constant level of about 130 beats/min. During transport no animal lay down but, rather, they intensively investigated the new surroundings. While unloading and weighing at the end of the transport, the heart rate values again increased. During transport the rectal temperature increased on average by 0.7°C (from 39.05 in stall to 39.70 immediately after transport). A rest period of 45 minutes was needed before these values dropped, but the initial

values in the stall were not reached in this time.
The authors also compared loading either with the tail-gate lift or by ramp. During loading with the tail-gate lift the heart rate dropped whereas ramp-loading led to a steep rise in heart rate. The initial value in the stall was 83.1 beats/min., during driving to the lorry 194.7 and during loading 217.8. A further investigation of the same authors showed, when limits of loading density (0.35 or 0.70 m^2/100 kg), temperature (2°C, 19°C, 29°C) and relative humidity (60 or 90%) are exceeded during transport special stress is placed on the pig. The testing of various combinations of these factors during constant duration of transport (100 min.) showed the strong influence of transport distance. In all situations the heart rate decreased with increasing duration of transport. The degree of decrease was influenced by respective treatment combinations.
Without considering relative humidity and loading density, transport at 19°C produced more favourable values than that at 2°C or 29°C. Relative humidity (60 and 90%) and loading density (0.35 and 0.70 m^2/ 100 kg liveweight) led to differing results in each temperature range. The values were obviously strongly influenced by varying levels of physical activity during thermoregulation and by the amount of room available.
The values at loading and at the end of transport were closely correlated. In many cases there was also a highly significant correlation between rectal temperature and heart frequency.
Augustini and Fischer (1977) estimated the degree of exhaustion with the help of a grading system. Slaughter pigs were transported for 100 min. with the above mentioned densities and temperatures. The highest degree of exhaustion showed pigs which were transported at a density of 0.35 m^2 and at temperatures of 19°C, and 29°C and at a humidity of 90%.

The lowest degree of exhaustion were observed in pigs which were transported at lower density (0.70 (m^2) and temperatures of 2°C with 60% humidity and 19°C with 60%. The activity after transport was highest in pigs which were transported at 19°C.

According to Mickwitz (1982) the heart rate during transport of slaughter pigs under practical conditions were influenced by times of feeding prior to commencement of transportation. He found that pigs fed 24 h-prior to the transport had the lowest heart rate during, and immediately after transport and during the rest period instead of animals which were fed 1, 4, 8 or 12 h prior to the transport.

Sybesma et al. (1978) reported on the cause of genetic constitution and deathrate. Investigations showed that the Malignant Hyperthermia Syndrome is genetically determined by a autosomal recessive hereditary trait. There are differences in susceptibility between different breeds. The meaty type Pietrain is more susceptible to stress than less meaty breeds. Only 3.1% of Large White pigs reacted halothane positive, while in Dutch Landrace 22.2%. The deathrate of halothane positive pigs during transport was 3.35%, whereas in none susceptible pigs deathrate was only a tenth of it (0.32).

The author reported on other experiments, in which from 172 crossbred pigs 44 pigs reacted positive. Of those during transport 3 animals died, while none of the 128 negative reacting pigs died. From 557 Dutch Landrace pigs, more than 226 reacted positive and 331 reacted negative. The losses were 13 and 7 (0.57% and 0.21%, resp.) The author concluded that effective selection for a pig more resistant to transport loss is possible.

5. Behaviour of pigs on transport

On a 7 day long journey from England to Italy by train Jackson (1973) observed no signs of restlessness which was not due to the pigs being either thirsty or hungry. The pigs did not appear to be affected by the movement of the wagon, although when violent shunting was being carried out, they were all on their feet, swaying in unison. They did huddle on few occasions when it became cold, but most of the time they were happily wandering around the pen, only becoming disturbed at meal times. All pens tended to behave in the same way even though they were well separated from each other. If one pen was sleeping, the other pens tended to be sleeping, if one pen had a few pigs on its feet and the rest sleeping the other pens were usually the same. One form of play was very noticeable. Each pen of pigs happened to have three metal rings located one foot above floor level. Much of the time pigs would be playing with these, sometimes two pigs would be playing with the same ring at the same time but more usually only one pig. The ring would be nosed and bitten by the pigs. The author concluded that rail travel is an excellent way of moving animals on long journeys provided they are accompanied. Augustini et al. (1977) observed pigs during transportation by road at different densities (0.35 and 0.70 m^2/pig) and temperatures (2°, 19°, 29°C). At low temperature during transportation pigs shivered with cold especially if the humidity was high. The higher animal density led to considerable motor activity until each animal found a place, then the pigs calmed down quickly. At 19°C the animals felt well at low density (0.70 m^2/pig) whereas in high density at the same temperature pigs showed high excitation and panic reactions. They calmed down very slowly. If there was at the same temperature the higher humidity many animals breathed heavily. According to Pearson and Killgour(1980) several authors considered that pigs do not fight during motion but do so when the vehicle is stationary. In addition a correlation has been found between the number of bites and the time the lorry was standing still. When the transport times were reduced by 50% by cutting out long stops the number of bites was reduced by 23%.

6. Some physiological responses of pigs to transport

Herding pigs to a lorry and subsequent transport led to increases in haemoglobin and hexokinase activity, indicating stress. The levels, however, returned to normal after 1.5 to 2 hrs rest. Blood values of haemoglobin, hexokinase and lactate were also lowered by a resting period at the slaughterhouse (Prange et al. 1977).

7. Sheep in transport

Platt (1982) recommends that sheep transported by sea should be allowed to make some adjustments before sailing because in the event of initial rough weather conditions injuries could be caused on overcrowded pens and inpartially occupied pens. According to the same author sheep are kept to about 50-60 head per pen. Each pen contains three feed and three water troughs. The daily ration of feed is about 1 kg/animal in two feeds, water is supplied continuously. The normal air flow is not sufficient to dissipate the levels of humidity and ammonia in the centre pens. There the installations of fans is indicated to disperse fumes when animals are resting.
After the author the most common diseases are those of respiratory and gastro-intestinal tracts, also infections keratitis (pink eye). With voyages of 10-14 days duration, there are significant loss of condition with accompanying sickness and mortalities during the latter half of the journey. Losses of 1.2 to 1.4% are not uncommon, which means 1000-1500 sheep die on the larger stock carriers.
If sheep are not kept separately with respect to the same age, higher deathrates among sub-adults arise. Carcass examinations showed that these animals could not compete for food with older and more aggressive animals. A more judicious grading system at the time of loading to separate animals is necessary. The author points out the importance of a rest of at least 24 h after embarkation before further transport.

8. Some physiological responses of sheep to transportation

Reid and Mills (1962) found that the cortisol and blood glucose level were less affected during transport in sheep accustomed to indoor housing compared with those taken directly from pasture. Pearson and Killgour (1976) took plasma cortisol levels at the time of throat cat, it has been found that the levels rise from a base of less than 10 ng/ml to 22.7 $\pm$ 6.0 ng/ml for travelling 20 km, 49.8 + 10.9 ng/ml for 30 km, 69.7 $\pm$ 19.2 ng/ml for 60 km and a peak of 77.9 $\pm$ 18.3 ng/ml for those travelling 100 km to the abattoir, even though the journey was on the day before slaughter. Greater distances travelled continued to give high levels of cortisol ranging between 61.0 $\pm$ 22.3 ng/ml and 76.3 ± 13.7 ng/ml, up to 225 km. As all the lambs arrived at the abattoir within a few hours of one another and were subjected to similar treatment, there appears to be some link between the distance travelled from the farm at the levels of plasma cortisol next day at slaughter.

According to Pearson et al. (1977) in transport up to 2 hours there is an increase of the mean level of cortisol. Subsequently there was a slight fall as travelling time further increased to 8 hours. Killgour and De Langen (1970) studied short term transportation in sheep. Using a fluorimetric assay they estimated a cortisol level of 66 ng/ml in 12 sheep after a 90 min. truck journey compared with minimal disturbance levels of 36 ng/ml.

9. Behaviour of sheep

Sutton and De Heever (1968) observed sheep on a long rail trip and they found that adult Merino sheep seldom lie down in railway trucks even on a 5-day journey. When rested after 2 to 4 days travelling without water or food no preference was shown, but after 5 days there was a preference for water. In the rest pens only 0.4 kg of lucerne hay per sheep was eaten in 24 hours, indicating that if the regulatory 4 h rest was given, very little food would be taken up. Ewbank (1975) concluded from studies on the road transport of store lambs indicating that after transport and return to their field, these lambs grazed for only 2 to 3 hours and spent the next 22 hours resting. According to Killgour (1976) where animals have not been able to lie down (older stock start to lie down for longer periods after long journeys) resting takes precedence over feeding on arrival at the destination. This was also the reaction of trucked calves during halting times.

10. Some physiological responses of poultry to transport

A significant effect of stress in poultry can be measured by the content of corticosterone and creatine kinase. Both increased significantly, reaching the highest concentrations following 4 hrs of transport (Scholtyssek & Ehringer, 1976). Besides stress this also indicates tissue damage as a consequence of transportation.

Corticosterone appeared to be correlated at a high level with the amount of loosely bound water. This is in agreement with other findings concerning meat quality. Water binding capacity had a minimum at 3 hrs following transport in combination with decreasing tenderness in breast and thigh meat (Gschwindt & Ehringer., 1979). Other blood parameters, as haemoglobin, haematocrit, serum proteins, lipids and cholesterol also showed significant effects due to transportation, which was reflected in meat pH too (Ehringer & Gschwindt, 1981). Another factor occurring in relation to transport is starvation. In broilers, exposed to stress situations as starvation and transport, a physiological imbalance developed (Gschwindt, 1977). Liver glycogen, microhaematocrit, total serum lipids and proteins changed significantly in a short time whereas blood glucose, serum cholesterol and creatine kinase were only significantly changed after longer periods of stress.