European Food Safety Authority

"The welfare of animals during transport"

Scientific Report of the Scientific Panel on Animal Health and Welfare on a request from the Commission related to the welfare of animals during transport

(Question N° EFSA-Q-2003-094)

Adopted on 30th March 2004

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1. TERMS OF REFERENCE

1.1. Background

The Scientific Committee on Animal Health and Animal Welfare (SCAHAW) was asked by the Commission services to report on the welfare of animals during transport with consideration of Directives 91/628/EEC and 95/29/EC and Regulation EC/411/98. On 11 March 2002, SCAHAW adopted a scientific opinion on "The welfare of animals during transport (details for horses, pigs, sheep and cattle)". The Commission sent to the European Food Safety Authority (EFSA) an extended mandate for the other species not covered in the previous report.

The mandate was accepted by the Panel of Animal Health and Welfare (AHAW) at the first Plenary Meeting, on 21st May 2003. It was decided to establish a Working Group of AHAW experts (TWG) chaired by one Panel member. Therefore the Plenary entrusted a Scientific report to a working group under the Chairmanship of Professor D.M. Broom, which has already considered the welfare of horses, pigs, sheep and cattle (see Report of the Scientific Committee on Animal Health and Animal Welfare adopted on 11th March 2002). The members of the working group are listed at the end of this report.

This Scientific Report (entrusted by the AHAW Panel to the TWG) is considered as basis for the discussion to establish the relevant conclusions and recommendations by the AHAW Panel.

1.2. Mandate

The working group was requested by the Scientific Panel on Animal Health and Welfare to draft a scientific report including the most update and available scientific data on the welfare of animals during transport with consideration of Directives 91/628/EEC and 95/29/EC and Regulation EC/411/98 which were not reported in the previous SCAHAW report from 11 March 2002. In particular on the effects on the welfare of the various species transported of: loading densities, travelling times, resting times, watering and feeding intervals and interactions of each of these with the use of upgraded or other vehicles and with any stress during loading and unloading. Other specific questions concern: the welfare of animals on roll-on roll-off vessels, especially during boarding, and the methods which operators and inspectors can use to monitor the welfare of animals during transport.

Species referred in the present report are: broilers, laying hens, turkeys, ducks, geese, pigeons, quails, ostriches and other ratites, deer, reindeer, rabbits, dogs, cats, rodents, primates, fish and exotic animals.

1.3. Scope of Report

The report presents general principles concerning how to achieve good welfare in animals of various species transported by different means. It also includes information pertaining to particular species and transport methods. In order to clarify the concepts, including the necessity to consider health as an important aspect of welfare, and to explain some of the scientific methodology reported, Chapters 2 and 3 briefly cover welfare assessment and links with disease. Chapters 4 and 5 refer to the role of the personnel involved in transport since they can have a great effect on the welfare of the animals. Chapters 2-5 are modified from the 2002 SCAHAW Report so as to refer to the species discussed in this report as well the fundamental science issues.

Information in this report is relevant to all animals which are handled or transported. The welfare of the animals can be affected whether they are in small or large numbers and whether transport is private or commercial. All those involved in animal transport have a moral obligation to consider the welfare of those animals and of others which might be affected by the transport.

The steps during transport include pre-transport preparation of animals and vehicles, planning for emergencies, inspection, loading, providing good vehicle conditions, monitoring of animals and conditions, and unloading with subsequent handling. There may be consequences for animal welfare of handling and transport, for example increased mortality, morbidity or other disturbance in the transported animals or increased disease incidence in other animals. All of these aspects are considered in the report. Most of the scientific evidence relating to transport of the species covered in this report concerns road transport. However, the information is generally relevant to rail and sea transport also.

The great diversity of species which are transported requires that there should be different chapters in the report for many of these. The amount of scientific work about the welfare of the animals during transport varies from substantial to about zero. In some cases extrapolation from one species to another is possible but great care and a good knowledge of the general biology of the species concerned are needed if this is to be done. As a consequence of the variation in the amount of evidence available, the chapters in this report vary in length and in detail. However, transport has to occur so the best possible basis for recommendations and legislation is presented in each chapter.

Animal transport has an impact on several aspects of biosecurity. Where information is available about effects on the transported animals or other animals, or personnel involved with transported animals, it is presented in this report. However, the wider-ranging issues of biosecurity are the subject of reports from other Committees.

2. THE ASSESSMENT OF ANIMAL WELFARE DURING TRANSPORT AND ASSOCIATED HANDLING

2.1. Concepts

The status of animals has been the object of philosophical concern for a very long time (see review by Ouedraogo and Le Neindre, 1999). In particular, there is concern in many countries about the effects of transport and associated handling on the welfare of animals. Animals are now defined as “sentient creatures” in European law and no longer just as agricultural products (Treaty of Amsterdam, 1997). That change reflects ethical public concern about the quality of life of the animals. Farm animals are subject to human imposed constraints and for a very long time the choice of techniques has been based primarily on the efficiency of production. However it is an increasingly held view that we should protect these animals against mistreatment, or better still, to allow them the maximum of good welfare.

In order to safeguard welfare and avoid suffering, a wide range of needs must be fulfilled. These needs may require the animal to obtain resources, receive stimuli or express particular behaviours (Vestergaard 1996, Jensen and Toates 1993). To be useful in a scientific context, the concept of welfare has to be defined in such a way that it can be scientifically assessed. This also facilitates its use in legislation and in discussions amongst farmers and consumers.

Welfare is clearly a characteristic of an individual animal and is concerned with the effects of all aspects of its genotype and environment on the individual (Duncan 1981). Broom (1986) defines it as follows: the welfare of an animal is its state as regards its attempts to cope with its environment. Welfare therefore includes the extent of failure to cope, which may lead to disease and injury, but also ease of coping or difficulty of coping. An important part of this state is that which involves attempts to cope with pathology, i.e. the health of the animal, so health is part of welfare. Furthermore, welfare includes pleasurable mental states and unpleasant states such as fear and frustration. Feelings are a part of many mechanisms for attempting to cope with good and bad aspects of life and most feelings must have evolved because of their beneficial effects (Broom 1998). Good welfare can occur provided the individual is able to adapt to or cope with the constraints to which it is exposed. Hence, welfare varies from very poor to very good and can be scientifically assessed. The word stress is used by some authors when there is failure to cope (Fraser and Broom 1990), but others use it for any situation in which an organism is forced to respond to environmental challenge (Selye 1980, Zulkifli and Siegel 1995).

The various mechanisms which exist within most animals for trying to cope with their environment and the different consequences of failure to cope mean that there are many possible measures of welfare. However, any one measure can show that welfare is poor. Measures which are relevant to animal welfare during handling and transport are described by Broom and Johnson (1993) and by Broom (2000).

Whilst the concepts mentioned above are relevant to all animals, some measurements used in welfare assessment, and some transport procedures, are specific to the type of animal in question. Therefore some aspects mentioned later in this chapter will not necessarily apply to all the species dealt with in this report. Whilst it is important to make it possible for poultry to lie down during transport, deer usually stand and obviously farmed fish do not lie down.

2.2. Behaviour measures

The most obvious indicators that an animal is having difficulty coping with handling or transport are changes in behaviour which show that some aspect of the situation is aversive. The animal may stop moving forward, freeze, back off, rapidly move away, vocalise or show other behaviours including lying down. The occurrence of each of these can be quantified in comparisons of responses to different races, loading ramps, etc. Examples of behavioural responses such as cattle stopping when they encounter dark areas or sharp shadows in a race and pigs freezing when hit or subjected to other disturbing situations may be found in Grandin (1980, 1982, 1989).

The extent of behavioural responses to painful or otherwise unpleasant situations varies from one species to another according to the selection pressures which have operated during the evolution of the mechanisms controlling behaviour. Human approach and contact may elicit anti-predator behaviour in farm animals, according to the animals' experience of interactions with humans (Hemsworth and Coleman 1998). Social species which can collaborate in defence against predators, such as pigs or man, vocalize a lot when caught or hurt. Species which are unlikely to be able to defend themselves, such as sheep, vocalize far less when caught by a predator, probably because such an extreme response merely would give information to the predator that the animal attacked is severely injured and hence unlikely to be able to escape. Cattle can also be relatively undemonstrative when hurt or severely disturbed. The action of natural selection has resulted in pigs which squeal when injured and sheep which may show no behavioural response to a similar degree of injury (Broom and Johnson 1993). Human observers sometimes wrongly assume that an animal which is not vocalising is not injured or disturbed by what is being done to it. In some cases, the animal is showing a freezing response and in most cases, physiological measures must be used to find out the overall response of the animal. The fact that fish do not vocalise out of water, and most humans are not familiar with any sounds or other behaviours of fish in water, may have contributed to the erroneous view that fish have little awareness or cognitive ability. During the loading and unloading of animals into and out of transport vehicles, Broom *et al.,* (1996a) and Parrott *et al.,* (1998a) showed that sheep exhibit largely physiological responses rather than behavioural and these are associated with the novel situation encountered in the vehicle rather than the loading procedure. Pigs, on the other hand, are much affected by being driven up a ramp into a vehicle, the effect being greatest if the ramp is steep Broom *et al.,* (1996b).

Individual animals may vary in their responses to potential stressors. The *coping strategy* adopted by the animal can have an effect on responses to the transport and lairage situation. For example, Geverink *et al.,* (1998) showed that those pigs that were most aggressive in their home pen were also more likely to fight during pre-transport or pre-slaughter handling but pigs which were driven for some distance prior to transport were less likely to fight and, as a consequence, cause skin damage during and after transport. This fact can be used to design a test which reveals whether or not the animals are likely to be severely affected by the transport situation (Lambooij *et al.,* 1995).

When hens are to be removed from a cage they move away from an approaching human. Broiler chickens or turkeys, which are much less mobile than hens, may not always move away from a person who is trying to catch them but, given time, their behaviour indicates that they are *disturbed by close human approach*. After poultry are picked up by humans they may struggle but often hang limply and if put down, show a freezing response (Broom 2000). The behavioural response to being caught and carried is generally one of passive fear behaviour and is frequently not recognised by the people handling them as indicating the severe disturbance which is revealed by physiological measures. An extreme example of this is the response of salmonid fish to being caught in a net and lifted into the air. A fish which is lying quietly will be showing the maximum adreno-cortical response possible (Pickering and Pottinger, 1985), although the persons handling the fish may be unaware of the very poor welfare caused by such handling. Removal from water is soon lethal for most fish, just as immersion in water is lethal for land animals. Consequently, a maximal physiological response is not surprising in either of these situations.

Once journeys start, some species of farm animals explore the compartment in which they are placed and try to find a suitable place to sit or lie down. Unfortunately for the animals, many journeys involve so many lateral movements or sudden brakings or accelerations that the animals cannot lie down. The number of pigs, or other animals, which remain standing during transport is a relevant measure of welfare in relation to the roughness of the journey. For example, Bradshaw *et al.,* (1996a) found that more pigs remain standing during a rough journey, measured in terms of accelerations in three possible planes, than during a smooth journey. In journeys with certain vibration characteristics, pigs show behavioural evidence of motion sickness in that they retch and vomit (Bradshaw *et al.,* 1996b, Randall and Bradshaw 1998).

An important behavioural measure of welfare when animals are transported is the amount of *fighting* that they show. This fighting is a consequence of social mixing rather than the transport itself. When adult male cattle are mixed during transport or in lairage, they may fight and this behaviour can be recorded directly (Kenny and Tarrant 1987). Calves of 6 months of age may also fight (Trunkfield and Broom 1990) and fighting can be a serious problem in pigs (Guise and Penny 1989, Bradshaw *et al.,* 1996c). The recording of such behaviour should include the occurrence of threats as well as the contact behaviours which might cause injury, for example those described by Jensen (1994) for pigs.

A further, valuable, method of using behaviour studies to assess the welfare of farm animals during handling and transport involves using the fact that the animals *remember aversive situations* in experimentally repeated exposures to such situations. Any stock-keeper will be familiar with the animal which refuses to go into a crush after having received painful treatment in it in the past or hesitates about passing a place where a frightening event such as a dog threat occurred before. These observations give us information about the welfare of the animal in the past as well as at the present time. If the animal tries not to return to a place where it had an experience then that experience was clearly aversive. The greater the reluctance of the animal to return, the greater the previous aversion must have been. This principle has been used by Rushen (1986a, b) in studies with sheep.

2.3. Physiological and biochemical measures

The physiological responses of animals to adverse conditions, such as those which they may encounter during handling and transport, will be affected by the *anatomical and physiological constitution* of the animal. Whenever physiological measurement is to be interpreted it is important to ascertain the *basal level* for that measure, the maximal level and how it fluctuates over time. For example, plasma cortisol levels in most species vary during the day and tend to be higher during the morning than during the afternoon. Physiological measures are summarised in Table 2.3.1.

Table 2.3.1. Commonly used physiological indicators of stress during transport

Stressor	Physiological variable
Measured in blood or other body fluids	
Food deprivation	↑ FFA, ↑ ß-OHB, ↓ glucose, ↑ urea
Dehydration	↑ Osmolality, ↑ total protein, ↑albumin, ↑ PCV
Physical exertion	↑ CK, ↑ lactate
Fear/arousal	↑ Cortisol, ↑ PCV
Motion sickness	↑ Vasopressin
Other measures	
Fear/arousal and physical	↑ Heart rate, heart rate variability↑, ↑ respiration rate
Hypothermia/hyperthermia	Body temperature, skin temperature

FFA, free fatty acids; ß-OHB, ß-hydroxybutyrate; PCV, packed-cell volume; CK, creatine kinase. (Modified after Knowles and Warriss 2000).

Heart rate can decrease when animals are frightened but in most farm animal studies, tachycardia, an increase in heart rate, has been found to be associated with disturbing situations. Van Putten and Elshof (1978) found that the heart rate of pigs increased by a factor of 1.5 when an electric goad was used on them and by 1.65 when they were made to climb a ramp. Steeper ramps caused greater increases up to a maximum level (Van Putten, 1982). Heart rate increase is not just a consequence of increased activity; it can be increased in preparation for an expected future flight response. Baldock and Sibly (1990) obtained basal levels for heart rate during a variety of activities by sheep and then took account of these when calculating responses to various treatments. Heart rate is a useful measure of welfare but only for short-term stressors such as those encountered by animals during handling, loading on to vehicles and certain acute effects during the transport itself. However, some adverse conditions may lead to elevated heart rate for quite long periods Parrott *et al.,* (1998a) showed that heart rate increased from about 100 to about 160 beats per minute when sheep were loaded on to a vehicle and the period of elevation of heart rate was at least 15 minutes. During transport of sheep, heart rate remained elevated for at least nine hours (Parrott *et al.,* 1998b). Heart rate variability is also a valuable measure of the welfare of animals, those individuals with greater variability being the most disturbed (van Ravenswaaij et al. 1993, Minero et al. 2002).

Direct observation of animals without any attachment of recording instruments or sampling of body fluids can provide information about physiological processes (Broom 1995). *Breathing rate*, or *gill ventilation rate* in the case of fish, can be observed directly or from good quality video recordings. The metabolic rate and level of muscular activity are major determinants of breathing rate but an animal which is disturbed by events in its environment may suddenly start to breathe fast. *Muscle tremor* can be directly observed and is sometimes associated with fear. *Foaming at the mouth* can have a variety of causes, so care is needed in interpreting the observations, but its occurrence may provide some information about welfare.

Changes in the *adrenal medullary hormones* adrenaline and noradrenaline occur very rapidly and measurements of these hormones have been little used in assessing welfare during transport. However, Parrott *et al.* (1998a) found that both hormones increased more during loading of sheep by means of a ramp than by loading with a lift. *Adrenal cortex* responses occur in most of the situations which lead to aversion behaviour or heart rate increase but the effects take a few minutes to be evident and they last for 15 min. to 2 h. or a little longer. Plasma corticosterone levels in hens at depopulation were three times as high after normal, rough handling than after gentle handling (Broom *et al.,* 1986, Broom and Knowles 1989) and those of broilers were three and a half times the resting level after 2 h of transport and four and a quarter times higher after 4 h or transport (Freeman *et al.,* 1984, and review by Knowles and Broom, 1990a). The cortisol response to handling and transport depends upon the species and on the breed of animal studied (Hall *et al.,* 1998a). When sheep were loaded on to a vehicle for the first time, all showed elevated plasma and saliva cortisol for at least the first hour (Broom *et al.,* 1996a, Parrott *et al.,* 1998b). Cortisol levels in transported pigs were affected by being on a rough rather than a smooth journey (Bradshaw *et al.,* 1996b), being mixed with pigs from different origin and being on a moving vehicle rather than being stationary (Bradshaw *et al.,* 1996c).

Animals that have substantial adrenal cortex responses during handling and transport show increased body temperature (Trunkfield *et al.,* 1991, Parrott *et al.,* 1999). The increase is usually of the order of 1 C but the actual value at the end of a journey will depend upon the extent to which any adaptation of the initial response has occurred.

In humans, *vasopressin* increases in the blood when the individual reports a feeling of nausea associated with motion sickness. Pigs also show motion sickness, retching and ejection of gut contents, especially when travelling along windy roads. These physical signs of motion sickness occur at the same time as increases in the levels of lysine vasopressin in the blood. Bradshaw *et al.,* (1996b) showed that increased vomiting and retching in pigs coincided with higher levels of lysine vasopressin.

The measurement of *oxytocin* has not been of particular value in animal transport studies (e.g. Hall *et al.,* 1998b). However, elevated oxytocin concentration in blood is associated with pleasurable sensations in several different types of circumstances (Carter, 2001). Plasma *ß-endorphin* levels were found to increase during the loading of pigs (Bradshaw *et al.,* 1996b) and measurement of beta-endorphin levels in blood is useful to complement ACTH or cortisol measurement.

Creatine kinase is released into the blood when there is muscle damage e.g. bruising, and when there is vigorous exercise. It is clear that some kinds of damage which affect welfare result in creatine kinase release so it can be used in conjunction with other indicators as a welfare measure. *Lactate dehydrogenase* (LDH) also increases in the blood after muscle tissue damage but increases can occur in animals whose muscles are not overtly bruised or cut. Deer which are very frightened by capture show large LDH increases (Jones and Price 1992). The isomer of LDH which occurs in striated muscle (LDH5) leaks into the blood when animals are very disturbed so the ratio of LDH5 to total LDH is of particular interest.

When land animals are transported they will be deprived of water to some extent. The most obvious and straightforward way to assess this is to measure the *osmolality* of the blood (Broom *et al.,* 1996a). When food reserves are used up there are various changes evident in the metabolites present in the blood. Several of these, for example *beta-hydroxybutyrate*, can be measured and in some species indicate the extent to which the food reserve depletion is serious for the animal. Another measure which gives information about the significance for the animal of food deprivation is the delay since the last meal. Most farm animals are accustomed to feeding at regular times and if feeding is prevented, especially when high rates of metabolism occur during journeys, the animals will be disturbed. Behavioural responses when allowed to eat or drink (e.g. Hall *et al.,* 1997) also give important information about problems of deprivation. Lack of oxygen, which is seldom a problem during the transport of land animals, is the greatest problem during the transport of fish since disturbed fish rapidly remove dissolved oxygen from water within transport containers. This can be assessed by measuring the concentration of dissolved oxygen in the water and on long journeys the concentration of toxic fish products, such as ammonia, can also be measured.

The *haematocrit*, the proportion of red blood cells in the blood, is altered when animals are transported. If animals encounter a problem, such as those which may occur when they are handled or transported, there can be a release of blood cells from the spleen and a higher cell count (Parrott *et al.,* 1998b). More prolonged problems, however, are likely to result in reduced cell counts (Broom *et al.,* 1996a).

A change which can be mediated by increased adrenal cortex activity and which may provide information about the welfare of animals during transport is *immunosuppression*. One or two studies in which animal transport affected T-cell function are reviewed by Kelley (1985) but such measurements are likely to be of more use in the assessment of longer-term welfare problems.

In the course of a journey, pathological conditions may arise or become exacerbated. The extent of such effects can be assessed by clinical examination as well as by other measures of welfare.

2.4. Mortality, Injury and Carcass Characteristics

The term welfare is relevant only when an animal is alive but death during handling and transport is usually preceded by a period of poor welfare. *Mortality records* during journeys are often the only record which give information about welfare during the journey and the severity of the problems for the animals are often only too clear from such records. The number of pigs which were dead on arrival at the slaughterhouse was 0.07% in the UK and The Netherlands in the early 1990s although the situation was worse in the past, especially with the

Pietrain and Landrace breeds. The level in the Netherlands in 1970 was 0.7%. Recent estimates of the numbers of broilers and laying hens dead on arrival at UK slaughterhouses are 0.4% and 0.5% respectively but mortality of laying hens has been reported to be up to fifty times higher on occasion (Knowles and Broom, 1990b). The mortality of fish, wild mammals, birds, reptiles or amphibians after transport in very poor conditions may even reach 100%.

Amongst extreme injuries during transport are *broken bones*. These are rare in the larger animals but poor loading or unloading facilities and cruel or poorly trained staff who are attempting to move the animals may cause severe injuries. It is the laying hen, however, which is most likely to have bones broken during transit from housing conditions to point of slaughter, (Gregory and Wilkins 1989), especially if the birds have had insufficient exercise in a battery cage, (Knowles and Broom 1990a).

Measurements made after slaughter can provide information about the welfare of the animals during handling, transport and lairage. *Bruising*, lacerations and other superficial *blemishes* can be scored in a precise way and when carcasses are down-graded for these reasons, the people in charge of the animals can reasonably be criticised for not making sufficient efforts to prevent poor welfare (Guise and Penny 1989). The cost, in both senses, of dark firm dry (DFD) and pale soft exudative (PSE) meat is even greater than this. DFD meat is associated with fighting in cattle and pigs but cattle which are threatened but not directly involved in fights also show it (Tarrant, personal communication). PSE meat is in part a consequence of possession of certain genes and occurs more in some strains of pigs than others but its occurrence is related in most cases to other indicators of poor welfare (Tarrant 1989). Poultry meat quality can often be adversely affected for similar reasons.

When animals are subjected to violent handling and they respond by an energetic struggle a possible consequence is capture myopathy. The muscle damage which occurs will impair muscular action in the future, at least in the short-term and is an indicator of poor welfare because it reduces coping ability and may be associated with pain (Ebedes et al., 2002a).

3. INFECTIOUS DISEASES AND WELFARE RELATED TO TRANSPORT

Transport and associated handling can negatively influence the health of transported animals and those that come in direct or indirect contact with them. As health is an important factor affecting welfare, any increase in disease will therefore result in poor welfare of the animal. Injuries causing different forms of tissue damage, malfunctions or other transport-related diseases are dealt with elsewhere in this report, therefore infectious diseases developing as a result of transport are the focus of the following section.

3.1. Processes involved in the spread of infectious agents

The occurrence of infections and infectious diseases in transported animals can result from pathogens already present in these animals before the transport and from pathogens directly or indirectly transmitted between the transported animals during or subsequent to the transportation. In the latter case the infections can be spread also to non-transported animals, e.g. animals present on a farm receiving the transported animals. This is a situation which typically occurs in the poultry industry in multi-age farms. Such spread of infections between transported and non-transported animals can also occur prior to transport e.g. during the collection process when for example different farms may be visited to collect animals for a particular transport consignment. A significant source of infections can also be transport vehicles and related equipment, in particular vehicles being contaminated by infectious agents. Persons involved in the transport procedure are also important vectors of infectious agents.

With reference to the poultry industry, removal of birds to reduce stocking density or to slaughter early results in increased stress in the poultry house and increases the risk of infection for the remaining flock, especially when outside workers and insufficiently disinfected equipment such as broiler collectors, crates and loading vehicles (e.g. broiler harvester) are used.

3.2. Factors involved in the development of infection and disease following exposure

3.2.1. General

Exposure to pathogens does not necessarily result in infection or disease in an animal. Factors influencing this process include the virulence and the dose of pathogens transmitted, route of infection and the immune status of the animals exposed (Quinn et al. 2000)

3.2.2. Transport-related factors - increased susceptibility to infection

A variety of stressors are associated with transport. In addition, poor welfare can adversely affect the ability of the body defence systems, especially the immune system, to deal with infection or exposure to infectious agents. The links between poor welfare and immuno-suppression are reviewed by Broom and Johnson (1993) and Broom and Kirkden (2003).

As an example, administration of glucocorticoids which increases adrenal cortex activity as well as introduction of new animals to established chicken flocks result in increased susceptibility to challenge with Marek's disease virus (Gross and Colmano 1969, 1971). The stressing activity including fighting caused by mixing different groups of pigs can also depress anti-viral immunity in these animals (de Groot et al. 2001).

The combined action of different stressors often has a multiplying rather than additive effect. While the transport process in itself already represents a combination of stressors, further management actions prior to transport can be additionally detrimental. As an example, weaning of young animals just before transport removes access to immunoglobulins in milk which is important in providing the mucosal immune protection to common enteric pathogens. Disease conditions are then more likely to develop in these animals since they often have a declining maternal immunity.

It is therefore to be expected that transport-related stress situations increase the susceptibility to infection through lowering the infection threshold, or the amount of pathogen needed to initiate an infection in an animal.

Many reports describing the relationship between transport and incidence of specific diseases have been published. Typically, 'shipping fever' is a term commonly used for a specific transport-related disease condition in cattle. It develops between a few hours and 1-2 days after transport. Several pathogens can be involved such as *Pasteurella* species, bovine respiratory syncytial virus, infectious bovine rhinotracheitis virus and several other herpes viruses, para-influenza 3 virus, and a variety of pathogens such as rotaviruses, *Escherichia coli* and *Salmonella spp* associated with gastrointestinal diseases (Quinn et al, 2000).

Transport in general has also been shown to result in increased mortality in calves and sheep (Radostits et al., 2000, Brogden et al., 1998), salmonellosis in sheep (Higgs et al., 1993) and horses (Owen et al., 1983). In calves, it can cause pneumonia and subsequent mortality associated with bovine herpes virus–1 (Filion et al., 1984), as a result of a stress-related reactivation of herpes virus in latently infected animals (Thiry et al., 1987). The presence of viral infections increases the susceptibility to secondary bacterial infections (Brogden et al., 1998).

3.2.3. Increased shedding of infectious organisms during transport

Transmission of a pathogenic agent begins with shedding from the infected host through oro-nasal fluids, respiratory aerosols, faeces, or other secretions or excretions. The routes of shedding vary between infectious agents.

Stress related to transport can increase the amount and duration of pathogen shedding and thereby result in increased infectiousness. This is well described for salmonella in various animal species (Wierup 1994).

The shedding of pathogens by the transported animals results in contamination of vehicles and other transport-related equipment and areas e.g. in collecting stations and markets. This may result in indirect and secondary transmission. The more resistant an agent is to adverse environmental conditions, the greater the risk that an agent may be transmitted by indirect mechanisms.

3.3. Effects of transport on transmission and disease

As can be seen from the above the transportation of animals can be an efficient mode of spreading infectious animal diseases and, in the case of zoonotic agents such as Salmonella subsequent spread can also involve humans. Except where animals are to be slaughtered very soon after transport, such infections can be of considerable importance through their effect on the welfare of the animals and the economic impact on animal production. If infections included in the OIE List A occur in transported animals, the economic and welfare consequences can be disastrous. This is well documented for most epizootics and also during recent years e.g. when in 2001 FMD was transmitted within and outside the United Kingdom. Schlüter and Kramer (2001) summarise the outbreaks in the E.U. of foot and mouth disease and classical swine fever in farm livestock. In relation to classical swine fever, they found that, once the disease was in the farm animal population, at least 9% of further spread was caused by animal transport. In a recent epidemic of Highly Pathogenic Avian Influenza virus in Italy it was found that the movement of birds by contaminated vehicles and equipment created a significant problem in the control of the epizootic.

3.4. Measures to prevent the spread of infectious diseases through transport

3.4.1. Mammals

Generally various actions can be undertaken to prevent the spread of infections in relation to transport. Of primary importance as a major preventive measure against the spread of diseases through transportation is good health quality in the herd of origin. Only animals of the same health quality should be transported together. It is important that there is a clinical examination of the animals before transport, as well as biosecurity measures including cleaning and disinfection of transport vehicles and related equipment. Unless there is a satisfactory level of welfare of the animals to be transported they will be more likely to develop clinical signs of disease.

However, if animals are in the incubation phase of a disease process or latently infected, they may well appear healthy even when checked by a veterinarian prior to transport, but they may develop the disease during or subsequent to the journey. Thus it needs to be recognised that a physical examination/inspection is unlikely to detect infected animals without symptoms of clinical disease and thereby prevent them from being transported. It is therefore important that the inspecting person is well informed about the actual disease situation in the respective herds and in the region of origin. Additionally specific precautions need to be considered in order to prevent the spread of specific diseases. Such precautions can include demands to include the herd or flock of origin in the inspection as well as testing and quarantine isolation prior to or post transport. Most transported animals today will rarely be inspected by a veterinarian but instead by a properly trained stockman or just by a truck driver with little or no knowledge or training in inspection of animals for transport. Thus, the disease-preventing effects of inspection also vary with the training and knowledge of the inspectors as well as with the quality of their inspection.

The control of infectious diseases of significant economic or zoonotic importance such as those included in OIE List A and some other diseases is subject to specific regulations (e.g. Council Directive 64/432 EEC; CE, 1964). In the EU, the objective is to ensure that animals infected with agents causing these diseases are not introduced into the community and not transported within the EU. In the case of suspicion of an outbreak of such a disease, legally based and specified actions and precautions are instantly undertaken to prevent the spread of the infection e.g. by transportation of animals.

3.4.2. Poultry

The general principles presented (comment: to my mind we here do not present guidelines, merely general statements) above for mammals (above) are valid also for poultry. The main difference which exists in the poultry industry is that the primary vehicle of infectious agents inside a farm or to the birds being transported is contaminated equipment associated with transport. Therefore, in addition to the specific disinfection guidelines for vehicles mentioned above, similar guidelines should be foreseen for loading equipment used in the poultry industry.

3.4.3. Fish and other aquaculture species

The basic principles for the prevention of infectious diseases by transportation of fish are similar to those for mammals. Stress is an important factor and e.g. various treatments which increase adrenal cortex activity in trout suppress immune function and increase disease incidence (Pickering and Pottinger, 1985).

The OIE Fish Disease Commission (FDC) has laid down two lists of significant diseases. One is a list of 13 'diseases notifiable to the OIE' and the second a list of 18 'other significant diseases of aquatic animals'. These diseases, all serious and responsible for heavy losses in their target species are classified on the basis of their socioeconomic importance, geographical range and aetiology (Hastein 2003).

In most cases these diseases may spread from an initial focus by movement of carcases, wild animals and birds or fomites, but the most serious route is generally through the transport of live fish. For this reason, there are within Europe designated disease free zones into which fish from other, non-certified areas of Europe cannot be transferred. In the case of aquaculture species this system is rigorously enforced by national and EU legislation, though in the case of many aquarium species, controls are not so strictly enforced, despite the risks being similar.

There are also a number of diseases which have serious welfare and economic impact which are endemic but only manifest themselves clinically when fish are stressed for some other reason, and transportation is one of the principal stressors in terms of such clinical manifestation. Many of these diseases are associated with surface microbial contaminants, which are enabled to become invasive pathogens due to handling or transport damage creating excessive mucoid responses or a portal of entry. Thus clinical examination of fish before transportation and a biocidal bath is frequently of great value in reducing transport losses.

Thus, there are strong reasons for ensuring that biosecurity measures are in place in relation to all stocks prior to and post transportation and it is also important to ensure that water from closed transport systems is not disposed of without disinfection post transport. Most closed transport systems currently eject the transport water with the fish at the point of discharge. Disinfection of the transport tank usually follows, but there is not usually any means of disinfecting the transport water. In quarantine systems such as that of the Ausvet (http://www.aahc.com.au/ausvetplan/) plan programme in Australia, water accompanying, for example, imported aquarium fish, is disinfected at the quarantine station.

Another major cause of disease losses in relation to transport by open system such as well boat or towed cage is the exposure of the fish to toxic algal blooms or swarms of toxic jellyfish within the water they are travelling through. These may be difficult to identify but skippers of transport vessels should keep close watch of both the sea and the stocks, to avoid such risks wherever possible.

Whatever the means of transport being used, the vessel, truck and/or transport tanks must be disinfected between each transport in order to avoid the transfer of pathogens between consignments transported in the same containers.

With the advent of very large well boats used for slaughter transportation as well as smolt movements there is a much greater risks of transfer of infection and of major welfare problems in the event of any breakdown, storm damage or toxic bloom event. Thus there is a need for greater controls over movements of such vessels and very strict guidelines with regard to disinfection, locations where such disinfection can be performed and where potentially contaminated water can be discarded.

4. INSPECTION

4.1. Inspection before and during transport

Animals may be inspected before, during and after transport. Animals which are to be transported could be unfit to travel because they are injured or diseased or could be fit to travel only in conditions which are better than those which are the minimal ones permitted by law. Decisions about fitness to travel are discussed below and in the Federation of Veterinarians of Europe Position Paper "Transport of Live Animals" 2001. When animals transported for slaughter arrive at a slaughterhouse a pre-mortem inspection is required. Decisions about disease conditions at either of these times require veterinary expertise.

Road vehicles carrying livestock may also be inspected by border crossing inspectors, the police, or animal protection inspectors in order to check vehicle design, conditions of animals, or other compliance with legislation. However, most inspections of transported animals are those carried out by the person responsible for the animals at the place of origin or during the journey.

Except where the journey is very short and the animals are in containers which are such that inspection is not possible, the person responsible for animals at the point of origin and the driver of the vehicle or other person responsible for the animals during the journey should have the ability to evaluate animal welfare, at least to distinguish an animal which is dead, injured or obviously diseased or distressed. Some of the methods of assessing animal welfare described in Chapter 2 can be used, together with the range of observations mentioned in the Recommendations of the Committees of the Council of Europe Conventions on the Protection of Animals Kept for Farming Purposes and on Animals during Transport. A person driving a vehicle containing livestock will need to check the animals in the vehicle at regular intervals during a long journey and after any situation which might cause problems for the animals, such as a period of excessive vehicle movement, a period when overheating might have occurred, or a road accident. The intervals between regular checks correspond to the intervals between rest periods which are prescribed by law for drivers.

The checking of animals involves visual inspection and awareness of auditory and olfactory cues that the animals have problems. It is necessary that each individual can be seen so the design of vehicles, distribution of animals in the vehicle and stocking density must allow for this. When fish are transported, oxygen concentration and other aspects of water conditions need to be monitored. If animals cannot be inspected, for example poultry which are put into stacked crates or sliding drawer units, on long journeys there are significant risks of poor welfare.

The veterinarian is the person ultimately best qualified to declare an animal fit or unfit for travel. The Federation of Veterinarian of Europe's Position Paper on the Transport of Live Animals (FVE, 2001) provides useful information on those conditions that render an animal unfit for travel. Basically, pregnant animals in the last 10% of the gestation period, animals that have given birth during the preceding 48 hours and newborn animals in which the navel has not completely healed are considered unfit for travel in all cases. Mammals or birds that are unable to walk unaided onto the container or vehicle because of serious disease or injury are considered to be unfit for travel in nearly all cases. A list of conditions that render an animal unfit for travel, which provides useful information, is presented in Table 2 (FVE 2001). Apart from the conditions listed by the Federation of Veterinarians of Europe, there are cases in which an animal can not be considered unfit for travel but yet deserves special consideration during transport, particularly during loading and unloading. Laying hens at the end of the laying period are an obvious example of this because they are prone to bone disorders so the risk of bone breakage is high during handling and to a lesser extent during transport.

Table 4.1.1 Animals Unfit to Travel (modified after FVE 2001).

1. Pregnant mammals in the last 10% of the gestation period

2. Animals that have given birth during the preceding 48 hours

3. Newborn animals in which the navel has not completely healed, e.g. not dried/fallen off. <u>Unfit for normal transport but exceptional provisions could be made:</u>

Mammals or birds that are, because of serious disease or injury, unable to walk unaided on to the container or vehicle (without e.g. the usage of electric goads or dragging) or which can be expected not to be capable of locomotion after transport unaided, such as:

4. Animals which are unable to rise to a standing position but will eat and drink

5. Animals, that experience severe pain when moving e.g. animals with broken extremities or a broken pelvis

6. Animals with large, deep wounds

7. Animals with severe haemorrhages

8. Animals with severe system disorders

9. Animals that are only able to stand after being forced (e.g. very weak, fatigued or emaciated animals) or fish which are unable to maintain their normal position in the water

10. Animals, that are lame to such a degree that they can put little or no weight on one of their legs

11. Animals with a uterine prolapse

12. Animals, that have just been undergone an on-farm operation such as de-horning or beak-trimming.

13. Animals, with visible cardiovascular or respiratory disorders, e.g. with forced inhalation, respiratory distress or gasping for air.

14. Animals with severe inflammation, e.g. due to mastitis or pneumonia

15. Animals, that lack coordination (e.g. animals that have difficulties keeping their balance, animals that have been given sedative drugs)

16. Animals, that have an obviously disturbed reaction to their environment (e.g. extreme agitation, disorder of nervous system, intoxication)

17. Animals with a substantial rectal prolapse

18. Animals with significant damage to living tissue

19. Blind animals

Inspection facilities are needed for the person on the vehicle who is responsible for the animals. It is often possible to check each individual large animal transported inside the vehicle without danger to the person inspecting or undue disturbance to the animals. However, other animals, such as groups of deer, cannot be inspected from inside the vehicle without danger to the person inspecting. In this case, external inspection facilities which allow each individual to be seen are necessary. Inspection of moderately-sized animals will normally be adequately done from outside provided that every individual can be seen. If inspection from inside the vehicle is required, the height of the deck must be sufficient for effective inspection.

If sick, injured or dead animals are found, the person responsible needs clear knowledge of, or instructions about, what to do. It is important that records are kept and made available to the competent authority, for example to veterinary inspectors, of all sick, injured or dead animals, including any disposed of during a journey. Where the animals are transported to slaughter, the abattoir as well as the owner of the animals will need a copy of the record. If an animal is found to be sick or injured on a journey, humane killing on the vehicle will sometimes be required. Hence, the responsible person on the vehicle will need to carry, and be trained in the use of, equipment for humane killing of the species carried. Where the injury or sickness is such that the animal cannot complete the journey, for example if it cannot stand unaided, the animal should be killed or unloaded as soon as possible at an appropriate place.

When animals die or are killed, the journey can continue for a time and to a place which is appropriate for the disposal of the carcass. In many cases of injury, sickness or death, it is important to inform the competent authority of the region. This is especially important if any important infectious disease is suspected. Journey plans include the addresses, e-mail addresses and telephone numbers of the competent authorities in each of the regions passed through during the journey.

5. TRAINING AND PAYMENT OF PERSONNEL

5.1. Training of personnel and payment to promote good welfare

One of the most important variables affecting the welfare of animals during transport is the behaviour of people who load and unload animals, or drive the vehicle (Lambooij et al. 1999). Those who are moving the animals may cause much fear or pain deliberately or accidentally. Those who drive vehicles may also contribute directly to poor welfare in the animals by driving too fast around corners, or by violent braking or acceleration. They may also subject animals to extremes of temperature by leaving vehicles stationary in direct sunlight during hot weather or by exposing animals to wind and low temperatures during cold weather. These problems can be addressed by education, good management and a method of payment which promotes good welfare rather than speedy completion of the journey.

Education of those responsible for animals during transport is essential if poor welfare during transport is to be minimised. There are many who drive road vehicles who do not know enough about animals to be able to care for a load of animals during a journey. As a consequence, training courses are needed by all who do such jobs. In some Member States such courses for livestock vehicle drivers are already provided. A legal requirement for a certificate issued after completion of an approved course is a valuable way of ensuring that persons with responsibility for large numbers of animals know how to prevent poor welfare in those animals. The driving standard for vehicles containing animals should be much better than those for human passengers who are supported in seats or standing with effective means of holding on and maintaining their balance. Most animal transport vehicle drivers are unaware of this so any requirement for training should also apply to those who already have experience in driving such vehicles. If the certification of drivers and others responsible for animals during transport can be withdrawn from those whose conduct warrants it, the improvement in the welfare of transported animals is likely to be greater.

A range of studies have shown that the method of payment of those who are responsible for animals during transport can have a considerable effect on animal welfare (Broom 2000). Guise (1991) found that if drivers received a bonus for reducing fuel consumption during animal transport, they drove more slowly, accelerated less and hence the animals were thrown about in the vehicles less, their welfare was better and the meat quality after slaughter was better. Similarly, Grandin (2000) reported that when drivers received a bonus if the meat quality after transport was above a certain standard, there was a dramatic improvement in animal welfare. Bonus payments or penalty deductions can be related to measurable quantities at the end of the journey to the slaughterhouse, in particular the number of animals dead on arrival, the number of animals found to have bruises or broken bones, and the number of animals with dark firm dry (DFD) or pale soft exudative (PSE) meat. In each case acceptable threshold levels need to be defined.

Where those who transport animals can insure against losses due to mortality, bruising, bone breakage, DFD meat or PSE meat, the incentive for drivers and others to treat animals well can be lost and welfare can be very poor. Normal insurance against road accidents poses no problem on animal welfare grounds.

6. Transport of Broilers and Hens

6.1. Introduction

There is a relatively large literature on the transport of poultry. This reflects both the size and importance of the poultry industry and the potential for adversely affecting both welfare and product quality. More has been published on the transport of broilers for slaughter than on the transport of laying hens. Relatively little information is available concerning detailed investigations of the transportation of day-old chicks and the most poorly studied category of bird in relation to transport appears to be the broiler breeder (or indeed all other breeding stock).

The available information on the handling and transport of broilers in relation to welfare has been reviewed by Nicol and Scott (1990), Knowles and Broom (1990a), Warriss and Knowles (1993) and Weeks and Nicol (2000). The welfare during transportation of one day old chicks has been reviewed by Mitchell (2002). The influence of ante-mortem handling on poultry meat quality was reviewed by Warriss *et al.* (1999b) and the consequences of pathophysiological conditions on quality discussed by Mitchell (1999). Information relating to laying hens was reviewed by Knowles and Broom (1990b) and Weeks and Nicol (2000). The effects of transportation on mortality in broilers were described by Bayliss and Hinton (1990).

The transportation of poultry constitutes the largest commercial translocation of a single class of livestock in the world. Despite regional economic pressures world-wide, poultry production continues to expand. The global statistics for poultry production indicate the magnitude and logistical complexity of the associated transport procedures. In the year 2000 the number of broiler chick placing worldwide was approximately 40 billion (FAOSTAT 2002) and in the European Union (EU-14) was around 4.3 billion. The corresponding figure for layer chicks was 290 million (EU-15) and for turkey poults 245 million (EU-14). The placement of broiler breeder chicks in the EU during the same period was approximately 30 million (Poultry Bulletin 2002).

All these birds are transferred from hatcheries to their sites of production or rearing within 1–3 days of their hatching and subsequently may be transported again for relocation or to slaughter and processing plants. It may thus be estimated that poultry experience in excess of 80 billion bird-journeys per annum. The majority of these journeys, particularly in the case of slaughter weight broilers, are by road and as well as considerations for animal welfare this "livehaul" and its associated problems are major determinants of the efficiency and profitability of large-scale commercial broiler production (Nilipour 1996). In addition the welfare of poultry during journeys is receiving considerable attention (e.g. Metheringham and Hubrecht 1996) resulting in pressure to improve conditions to safeguard animal welfare. The recent widespread outbreaks of Avian Influenza in Europe illustrate the potential importance of transport in the spread of disease between bird populations.

6.2. Chick transport

All production and breeder birds must originally be placed on rearing farms following transportation from centralised hatcheries. The number of chicks transported at this stage must equal the final production figures plus those lost (mortalities and culls) during transport, rearing or production. The birds are transferred from hatcheries within 1-3 days of their hatching. Chicks are transported mainly by road or in the case of breeder birds by air and road to these destinations. Chicks may be moved over relatively short distances in small numbers (e.g. pedigree birds, great grandparent lines) in high specification containers and vehicles or over much greater distances in less sophisticated systems. They are normally carried in specially designed disposable cardboard boxes. Thus day old broilers may be delivered from hatcheries to rearing farms over distances of 150 km or greater on vehicles which are several years old and which may not have the advanced ventilation and internal air mixing systems found on pedigree bird vehicles. This may lead to heterogeneity of the on-board thermal environment and consequent heat or cold stress. The detrimental effects of such conditions will be proportional to journey duration. This first journey may be regarded as a major threat to the welfare and later production efficiency of all birds. It is widely recognized that the husbandry of the birds during this period, and the conditions under which they are maintained immediately prior to and after placement, are vital in determining subsequent performance and health status (e.g. Decuypere et al. 2001; Langhout 2001). Transport is regarded as a major source of stress and reduced welfare in all species at all ages including poultry and a major cause of these problems is the thermal micro-environment in transit (Mitchell and Kettlewell 1998; Cockram and Mitchell 1999; Mitchell *et al.* 2001a; Hunter *et al.* 2001; Kettlewell and Mitchell 2001a; Mitchell 2002, Nilipour 2002). Many other factors may also contribute to transport stress such as handling, feed and water withdrawal, vibration, space restrictions upon behaviour, noise and pollutants (Weeks and Nicol 2000; Mitchell *et al.* 2001b). A small number of studies have addressed some aspects of the transportation environments of day old chicks but with a primary focus of minimizing in transit losses and maximizing subsequent performance. Transport conditions for one day old chicks have been reported as influencing subsequent incidence of ascites and "sudden death syndrome" (Maxwell and Robertson 1998).

6.2.1. The effects of transportation on chicks:

Thermal environment

Thermal stress may be the major source of poor welfare during the transportation of day old chicks. Whilst commercial breeders and producers have long recognized the necessity to maintain an appropriate thermal environment for chicks in transit (Tamlyn and Starr 1987; Laughlin 1989; Van der Hel and Henken 1990; Qureshi 1991; van der Hel *et al.* 1991) the conditions employed have been largely defined by empirical means and have been based upon minimization of mortality rates during and following transport and efficient productivity during the subsequent rapid growth phase. In current practice the recommended temperature for chick transport is 24-26ºC (Ross Breeders 1996; Meijerhof 1997; Weeks and Nicol

2000), although only the Ross Breeders paper (1996) includes a recommendation for controlled humidity (75% at 24°C).

Therefore, to simultaneously optimise survival, productivity and welfare of the newly hatched chick in transit an effective strategy would be to match the thermal characteristics of the microenvironment to the biological requirements of the birds. Some previous studies have attempted to define thermoneutral or optimal environments for neonatal chicks on the basis of metabolic heat production and body temperature responses (Misson 1976; Henken et al. 1989; Gates et al. 1989; van der Hel et al. 1991). Generally these studies did not measure other indicators of homeostatic effort which might better define the physiological impact of the thermal micro-environment. More recently Xin and Harmon (1996) examined the effects of a range of temperatures and humidities (20-35°C and 40-97%) upon day old chicks by measuring metabolic rate and mortality. They concluded that optimum or thermoneutral conditions occurred between 30-32°C. Xin (1997) has also reported that chicks held at a constant 29°C do not exhibit a different mortality or body weight loss compared with birds exposed to as much as a 16°C cycling temperature around the same mean temperature.

Mitchell et al. (1996a) have employed physiological stress modelling, measurement of metabolic rate and the concept of Apparent Equivalent Temperature or AET (Mitchell and Kettlewell 1998; Mitchell *et al.* 2001a, b) to determine optimum transport thermal environments for one day old chicks. Apparent Equivalent Temperature takes account of the humidity of the air and is therefore a better index that temperature alone of the physiological stress to which the bird is subjected. All measurements were performed on chicks in commercial transport containers in calorimeter chambers housed in controlled climate rooms. Temperatures of 20-35°C accompanied by relative humidities (RH) of 50-65% and durations of exposure from 3-12 hours were employed. Metabolic heat productions ranged from 7.8±0.3 to 8.7±0.9 Wkg^{-1} in close agreement with previously published values (van der Hel *et al.* 1991; Tanaka and Xin 1997a). On the basis of minimal change in body temperature and minimal alterations in basal metabolic rate, hydration state, electrolyte balance, body weight loss and plasma metabolite concentrations an optimal temperature-humidity range of 24.5-25.0°C and 63-70% RH for the transport of chicks at commercial stocking density was identified. It was emphasized that these physiologically ideal conditions are very similar to those currently employed by commercial breeders and producers. The studies also provided evidence that if the thermal micro-environment is appropriately controlled then journey durations of at least 12 hours are wholly acceptable. It is concluded that both productivity and welfare of day old chicks in transit can be maintained by careful regulation of the temperature and water vapour density to these prescribed limits inside the transport containers.

Between hatching and transport chicks are not offered feed or water but must rely on any nutrients remaining in the yolk sac. Modern genotypes have much higher metabolic rates than older breeds and the yolk sac stores are used up correspondingly more quickly. Modern chicks are therefore less well able to withstand long periods of inanition than chicks of 20 years ago. This is discussed further in Section 6.2.3.

Mortality and Physical damage:

There appear to be no accurate scientifically based surveys yielding estimates of mortality during road transportation of day-old chicks. Commercial practice often involves calculation of three day and seven or eight day mortality reasoning that these values (total losses from birds transported) integrate the overall effects of the transport process and placement. On this basis mortalities of 1.0-1.7% have been reported (Tanaka and Xin 1997a). There are no studies correlating such losses with road transport conditions and events. Similarly there are no reliable reports of the incidence and causes of injury during the transportation of chicks.

6.2.2. Effects of food and water deprivation in chicks

In many transported animals the physiological challenges presented by the thermal conditions are compounded by extended periods without access to food or water. It has long been thought that the one-day old chick may be partially protected from such stresses by the presence of energy and water reserves in the yolk sac. Older studies proposed that yolk stores in the newly hatched chick constitute 18% of total body weight and contain approximately 2g of lipid and 2.5 ml of water, which in the absence of excessive thermoregulatory demands represent energy (75-80 kJ) and water supplies sufficient for 3 days without further provision of food and water (MacLeod 1980; Freeman 1984). The work of Murakami et al. (1992), which was conducted at least 12 years ago, shows that domestic fowl chicks grew very fast using nutrients taken up from milk, on day one after hatching, grew rather more slowly on day two and grew little using yolk sac nutrients on day three because the yolk had largely gone by then. The energy content of the carcass of unfed birds dropped rapidly after day two and the lipid content dropped immediately after hatching but dropped faster after day two. The maximum relative growth rate of normal chicks was at 3-5 days of age. Noy et al. (1996), working seven years ago, described how: firstly the yolk sac drops in weight by a factor of ten to a very low level by 48 hours after hatching, secondly the uptake of oleic acid into the intestine is fast for the first ten hours of life and almost zero by 50 hours, and thirdly that the yolk stalk is initially open but is almost entirely closed by 48 hours after hatching. The trend towards faster development in broiler chickens has continued since this research was carried out so energy availability from yolk is likely to cease before 48 hours at a time when rapid nutrient utilisation is occurring.

Some more recent studies have suggested that in modern day old chicks high metabolic rate and rapid utilization of resources in the first 24 hours post-hatch coupled to delays in transit and placement result in poorer performance and health throughout flock life (Tanaka and

Xin 1997a; Xin and Lee 1997; Hackl and Kaleta 1997; Vieira and Moran 1999; Bigot et al. 2001). Major causes of in-transit and post-transport mortality and morbidity are dehydration and undernutrition (Xin and Lee 1997). A suggested strategy to reduce metabolic depletion during extended transport is the exploitation of the reduction in metabolic rate in crated chicks in the dark (Tanaka and Xin 1997a). The quantity and rate of use of metabolic reserves by basal metabolism, however, is clearly not the only factor that will influence chick survival during transportation.

The prevailing microenvironment may impose thermoregulatory and metabolic demands upon the chicks which will require the rapid mobilization and utilization of lipid or the evaporation of water. Neonatal chicks do not possess fully developed effective homeothermic mechanisms (Lamoreux and Hutt 1939; Freeman 1964; Dunnington and Siegel 1984) and consequently are vulnerable to the detrimental effects of thermal loads and fatigue and dehydration. In the immediate post-hatch chick both body temperature and metabolic rate increase (Freeman 1964), however body temperature remains labile during exposure to sub-optimal thermal environments (van der Hel et al. 1991). Thus, if the transportation environments are unduly hot or cold then immaturity of thermoregulatory homeostasis, including inadequacy of lipid mobilization or efficient evaporative heat loss during thermal polypnea may result in stressful or life threatening hypothermia or hyperthermia. In addition the accelerated rates of utilization of energy and water reserves may result in premature depletion. Freeman (1984) has estimated that reserves were completely exhausted in as little as 8-10 hours at a temperature of 40C.

6.2.3. Preparation for transport, loading and unloading of chicks

Newly hatched broiler chicks were kept for up to 48 hours without food and water and compared with a control group given access to food and water within 6 hours of hatching (Warriss *et al*, 1992b). Deprived chicks progressively lost body water and developed increases in plasma total protein consistent with a decrease in plasma volume. They lost weight at an average of 0.14% per hour and weighed 16.5g less than the fed chicks after 48 hours. A major concern for one day old chicks is extended post-hatch holding periods prior to transportation as these could lead to depletion on energy stores and to dehydration and have been shown to result in reduced performance and increased morbidity (Xin and Lee 1997). On road journeys the provision of nutrients or water is impracticable so the emphasis must be upon the standards of husbandry immediately upon arrival at the destination. No studies have addressed the methods of handling during loading and unloading of chicks.

6.2.4. *Floor/space allowance for chicks:*

No studies examining the effects of altered space allowances for day old chicks have been reported. A balance needs to be struck between high enough stocking densities so that the chicks' own heat production keeps the immediate environmental temperature high enough to prevent hypothermia, and allowing sufficient space that they are not cramped and possibly in danger of hyperthermia. Current recommendations of 21-25cm^2 of floor space per chick are used in practice.

6.2.5. *Vehicle design of chick transporters:*

The ultimate determinants of the localized on-board vehicle (chick transporter) micro-environment are the prevailing climatic conditions, the addition of heat and water vapour to the load space from all sources including the bio-load (chicks) and the ventilation rate and distribution. All these issues have been extensively addressed in relation to the transport of broiler chickens at slaughter age (e.g. Hoxey *et al.* 1996; Kettlewell *et al.* 2000) but the corresponding characteristics of chick transporters have received less detailed study. Up to date measurements of heat and moisture production of chicks are available for calculation of vehicle ventilation requirements (Tanaka and Xin 1997a; Mitchell et al. unpublished) but only the work of Quinn and Baker (1997) appears to have examined in detail the ventilation characteristics of commercial chick transporters. The important findings included the observation that the presence of the load of stacked chick boxes had a channelling effect upon the air flow through the load space with significant amounts of air by-passing the chick boxes and being re-circulated. The implications of this ventilation regime for air flow in the chick containers was seen in the temperature distributions with peak temperatures occurring in the front central boxes and cooler air by-passing the load. In addition, cooler air entered from beneath the vehicle in the fully loaded configuration and reduced flow through the load as well as potentially introducing exhaust fumes in to the load space.

6.2.6. *Air transport of chicks:*

Increasing numbers of chicks are transported by air over long distances and may be subject to delays and periods of holding in less than optimal conditions constituting significant welfare concerns. Schlenker and Muller (1997) claim high mortalities occur in air transit due to long periods of inanition and dehydration and that these problems will be significant if the birds are still in transit 48 hours after hatching and no food or fluids are provided. Air journeys are often preceded by long holding periods on the ground and holding periods and road transportation after arriving at the country of destination. This complex journey structure can promote the transportation stresses and lead to increased mortalities. In these circumstances mortalities appear to be closely correlated with journey durations (Xin and Rieger 1995 a, b). Eight journeys were studied involving 13-18 hours flying, 27-57 hours of ground operation, and thus 42-72 hours of total journey time.

Also it was clear that the factors leading to the high initial mortalities on extended journeys contributed to the longer term losses as SDM was related to DOA in a highly significant manner.

$$SDM = 3.53 + 4.17DOA \ (R^2 = 0.95)$$

Thus longer journeys are associated with higher mortalities in transit and elevated losses during the first week of life. It may be suggested that physiological stress during transportation may compromise subsequent immunocompetence, food intake and growth and be associated with the exacerbation of a variety of pathologies in the young chick thus resulting in increased losses during the first week post-hatch.

These problems are exacerbated when aircraft hold thermal conditions are poorly controlled on long haul flights. In the same studies a wide variation in aircraft hold conditions was observed. Chick container temperatures fell rapidly by up to 7°C upon departure and increased by up to 10°C upon touchdown. Stressful elevated temperatures were observed during holding on the aircraft prior to take off and again upon landing. The authors recommended that total journey time should be maintained below 45 hours in order to avoid "excessive mortalities". A further issue associated with aircraft hold conditions is the reduced barometric pressure and the reduction in water vapour density observed in the recycled air. Thus, whilst barometric pressure on the ground for the above journeys averaged 100kPa, in flight the value fell to 84kPa which will promote water loss (and dehydration) by altering the gaseous diffusion coefficient (Birchard 2000; Westerterp *et al.* 2000). This situation would be exacerbated by low ambient humidity or water vapour density. Recent unpublished studies (Mitchell and Kettlewell 2002) have monitored temperatures and humidities throughout the load space of both Boeing 747 and MD 11 freighter aircraft carrying animals on long haul flights. Temperature varied widely, and water vapour densities as low as $2gm^{-3}$ were observed. These conditions would encourage high rates of evaporation from both skin and respiratory tract and would result in potential dehydration and hypothermia in chicks under certain thermal loads.

The design of chick containers and their configuration in stacking has also been questioned (Tanaka and Xin 1997b). Inadequate passive ventilation flow through the boxes when chicks are held in warehouses prior to flights or during other holding periods in aircraft holds before take off and after landing quickly resulted in potential heat stress conditions even when external temperatures were only moderately warm. It is notoriously difficult to obtain estimates of ventilation rates for commercial aircraft transporting animals but the work of Xin and Rieger (1995b) demonstrated that air exchange rates through the chick containers were 3.67 $m^3\ h^{-1}\ kg^{-1}$ during flight and 9.03 $m^3\ hr^{-1}\ kg^{-1}$ during ground operations. These values are within the recommended ventilation rates for air transport of chickens. For all long distance transport of chicks it has been recommended that water and feed should be available in transit to reduce mortality and maintain welfare and productivity (Xin and Lee 1996; Xin 1997; Tanaka and Xin 1997a). Water may be provided in the form of commercial hydration gels, which are simply cut in to slices and placed in each container or box.

6.3. Broiler and Hen production systems and transport

(1) Broilers: Broilers are reared to a live weight of 2.0 to 2.5kg in about 6 weeks under intensive conditions. Extensively-reared birds take longer. The intensively-reared birds are housed in sheds holding up to 60,000 individuals, either in mixed or single-sex groups. The sheds are dimly lit, the birds are held at high stocking densities (up to 45 kg/m^2) and food and water are offered ad lib. Human contact is minimal. The birds are transported to processing plants where they are slaughtered. Transport is in loose crates or fixed crates (drawers), the latter being held in modules. Modular systems are increasingly popular.

(2) Hens: Hens are reared as pullets, reaching point of lay at about 18 weeks of age. They are transported to the egg producing farms where they are either housed in battery cages or in "alternative" systems. These consist of aviaries, percheries or "free range" runs. Alternative systems have become much commoner in Europe over the last decade. This trend will continue because the EU has banned the use of conventional battery cages from 2012. Hens have a productive egg laying life of about a year after which they are culled (as "spent" hens).

Spent hens are transported to processing plants where they are slaughtered. There are several particular concerns about this. The hens have a low monetary value and thus there is little economic incentive to encourage careful handling and good welfare. Because they lay eggs, which require large amounts of calcium, they tend to suffer from bones that contain less than optimal levels of calcium that are correspondingly weak. These are easily broken and high levels of recent breaks (29%), caused during depopulation of the housing systems, have been recorded in surveys of the problem (Gregory and Wilkins, 1989). By analogy with human experience, broken bones are almost certainly painful.

6.3.1. Transport times:

In a survey of records of the transport of 19.3 million broilers killed in four processing plants in the UK Warriss *et al*. (1990) found an average time from loading to unloading of 3.6h, with a maximum of 12.8h. A recent survey of poultry transport in France, based on responses to a questionnaire, found journey times for broilers of up to 3h, with averages of 1.2 to 1.3h. Although there seem to be no published data, spent hens are thought to travel very long distances to slaughter in the UK because of the very small number of plants willing to process them. This long transport must be a cause of some considerable concern.

6.3.2. *The effects of transport on poultry:*

There is evidence that the collecting, transport and handling of broilers is stressful (Duncan, 1989), leading to fear, as evidenced by tonic immobility measurements (Cashman *et al*., 1989). This is also seen in culled hens (Mills and Nicol, 1990). Handling, crating and transport of broilers are associated with physiological changes in the birds indicative of stress (Kannan and Mench, 1996; Freeman *et al*., 1984; Mitchell *et al*., 1992).

In transit the birds may be exposed to a variety of potential stressors including the thermal demands of the transport micro-environment, acceleration, vibration, motion, impacts, fasting, withdrawal of water, social disruption and noise (Nicol and Scott 1990; Mitchell et al. 1992; Mitchell and Kettlewell 1993; Mitchell and Kettlewell 1998). Each of these factors and their various combinations may impose stress upon the birds in transit but it is well recognized that thermal challenges and in particular heat stress constitute the major threat to animal well-being and productivity (Mitchell and Kettlewell 1998; Mitchell *et al.* 2000; Weeks and Nicol 2000; Mitchell *et al.* 2001; Nilipour 2002). Birds may suffer from thermal stress during transport. (Kettlewell, *et al.* 1993; Webster *et al,* 1993) and heat stress is thought to be a major factor in deaths (Bayliss and Hinton, 1990). Mortality is also increased with increasing journey time (Warriss *et al*., 1992a). The imposition of thermal loads upon the birds in transit will thus result in moderate to severe thermal stress and consequent reduced welfare (Mitchell *et al.* 1992; Mitchell and Kettlewell 1998; Mitchell *et al.* 2001), increased mortality due to either heat or cold stress (Hunter *et al.* 2001) and induced pathology including muscle damage and associated changes in product quality (Gregory 1998; Mitchell 1999).

Birds may suffer physical damage, especially during catching, this taking the form of broken bones, bruising and haemorrhaging (Nicol and Scott, 1990 Knowles and Broom, 1990a; Warriss and Knowles, 1993; Warriss *et al,* 1999b; Weeks and Nicol, 2000).

It is generally not known which of the various potential stressors, imposed on birds in transit and during the associated handling procedures, is perceived by the birds to be most important. Recent work (MacCaluim *et al.,* 2003) suggests that when broilers are presented with both thermal and vibration potential stressors at the same time they find only the thermal stress aversive.

Mortality

Weeks and Nicol (2000) suggested a conservative figure for overall average mortality during the transport of broilers as 0.3%. Very high mortality rates are occasionally recorded. Swarbrick (1986) cites a case of 26% of culled hens, and Warriss *et al*. (1992a) recorded a case of 15% of broilers, in single loads. Because of the numbers of birds transported these percentages translate into very large absolute numbers of birds dead on arrival (DOA) at the processing plant whose welfare has been severely compromised. A major causal factor is heat stress, but many birds also die of traumatic injuries (Gregory and Austin, 1992). Reduced mortality will therefore result from closer control of environmental conditions during transit and more careful bird handling to reduce trauma (Warriss *et al*, 1999). It will also result from shorter journey times (Warriss, *et al*., 1992a) Broilers suffering from existing conditions such as ascites are probably more prone than healthy birds to dying during transport..

Even at a rate of 0.2 –0.3% mortality is much higher than would be expected in non-transported birds. Based on published figures for mortality during the rearing period, Warriss et al. (1996) estimated that journeys of up to 4 hours increased mortality by about ten-fold and journeys over 4 hours nearly 19-fold. More recent studies (Hunter *et al.* 1997; 2001) have examined the causes and distributions upon the vehicle of Dead on Arrivals during commercial broiler transportation during different times of the year. A total of 26 journeys were studied using both curtains open and closed at the appropriate times of the year. The findings indicated that, as might be predicted, mortalities due to existing pathology or catching injury were randomly distributed across the bio-load and were unaffected by season, whereas those attributable to transport stress had very high incidences in specific locations upon the vehicle. In ‘curtains-open’ configuration overall mortality was low (0.12%) and up to 90% of this figure was attributable to pathology and physical damage or injury. On journeys employing the ‘curtains-closed’ configuration mortalities as high as 0.93% were recorded and 95% of these were a consequence of "transport (chiefly thermal) stress". The vast majority (>75%) of these DOAs came from the "thermal core" of the vehicle or close to the air inlets of lorry and trailer.

Transport of broilers leads to an average mortality of about 0.2-0.3% (i.e. 11 million out of 4.3 billion in E.U.) and mortality rate increases with the length of the journey. A large-scale study found that transport for up to 4 hours increased mortality 10-fold over on farm levels for a comparable time and that in journeys longer than 4 hours mortality was 0.283 as compared with 0.156 in journey less than 4 hours (see Figure 6.3.2.1)

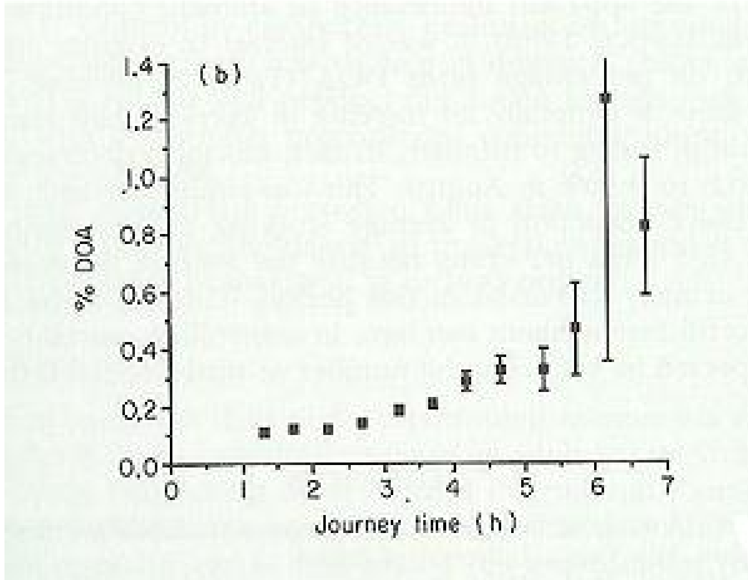

Fig 6.3.2.1. Using data from a study of 3.2 million broiler chickens, the percentage of birds dead on arrival is plotted against the journey time in hours (mean and standard error). Mortality increased with journey time ($p<0.001$), increasing after 4 hours and increasing more rapidly after 6 h (Warriss et al. 1992a).

Physical damage

Lack of care during handling can lead to broken bones, dislocated bones, bruising, internal haemorrhages and crushing injuries. All these conditions are important from the point of view of meat quality, as well as welfare, because they downgrade the value of the meat. In poultry it is important to distinguish between breaks and bruises occurring during antemortem handling and those occurring at the point of slaughter, usually because of the stunning procedure. For example, bruising in turkeys over the keel bone was initially wrongly attributed to electrical stunning but was shown to be actually caused by the birds hitting the front lip of the transport module during loading (L J Wilkins, personal communication). Damage occurring before stunning has welfare implications (the birds are still conscious) while that occurring subsequently has not (once effectively stunned the birds are insensible).

Levels of bruising appear to range very widely from 2.6% in the UK (Mayes, 1980), through 3.5 – 8.0% in Australia (Griffiths and Nairn, 1984) to about 20% in the USA (Taylor and Helbacka, 1968). There are alleged differences in susceptibility between bird strains, sexes and degree of muscling.

Gregory and Wilkins (1990) found that 3% of live broilers had broken bones caused by preslaughter handling and 4.5% had dislocated femurs. However, the level of dislocations can be much higher. In a later study (Gregory and Wilkins, 1992) the level of dislocations was 27%.

Broken bones are a very serious welfare problem in laying hens. These have relatively weak bones because of reduced mineralization associated with use of body calcium for egg shells, and a restricted opportunity to exercise in the case of birds housed in battery cages. Knowles and Broom (1990b) showed that the wing bones of battery hens were only about half as strong as those from perchery birds, where wing exercise was possible, and the bones were correspondingly strengthened. Bones are often broken during catching at depopulation. Gregory and Wilkins (1989) found that 29% of battery hens had broken bones immediately before slaughter. Gregory *et al.* (1990) later showed that on average 24% (range 13 to 41% over 8 flocks) of battery hens had broken bones after removal from their cages, but before transport.

Birds, whether broilers or culled hens, with unhealed old bone breaks, or fresh breaks, could not legally be transported under current EU legislation because transportation would inevitably lead to greater potential pain and suffering, therefore making the birds unfit for transport (see Table 4.1.1.).

Thermal stress

Both environmental temperature and humidity (water vapour density) are important factors affecting welfare. An important method of losing heat in poultry at high temperatures is by evaporative cooling from the respiratory tract. The birds pant to facilitate this. At high humidity evaporative mechanisms become less effective, or ineffective. Because of the way the crates or module drawers are stacked on the transport vehicle airflow is severely restricted. A major problem is therefore dissipation of waste heat generated by birds in the centre of the load. Conversely, birds on the outside of the load may be exposed to the elements. To protect them from becoming cold and wet, in inclement weather, and especially in winter, side curtains are used. However, by further restricting airflow, these may compromise the welfare of the birds in the centre of the load even more. Without side curtains, ventilation of the load is probably just sufficient when the vehicle is moving but becomes problematic when it is stationary. However, when stationary, lack of ventilation in vehicles fitted with side curtains may lead to hyperthermia in many of the birds. Long periods of panting may also cause dehydration. Low ambient temperatures appear generally to be less important as a welfare concern. However, birds can become hypothermic, especially if they are poorly feathered, wet or dirty, and are subject to the effects of wind chill (Weeks and Nicol, 2000). It is therefore important that poorly-feathered birds, such as many spent hens, are not exposed to low temperatures during transport.

The importance of wet plumage in increasing body heat loss, particularly during simultaneous exposure to both low temperatures and significant air movements (air velocities of 0.5 ms^{-1} or greater), was demonstrated by Mitchell *et al.* (1997). In this study the effects of wetting upon deep body temperature were studied in broilers exposed to a range of temperatures between +12° and –4° C. The responses in dry birds and groups intermittently wetted by a fine water spray were compared. In the absence of wetting the largest fall in mean deep body temperature (1.21±0.73C) during three hours of exposure was observed at the lowest chamber temperature (-4C) although this was not significantly different from the decrease (0.96±0.88C) following a 3 hour exposure to the highest environmental temperature (T_e) of 12C. Surface wetting, however, had a profound effect upon thermoregulatory ability of all birds with an increasing degree of hypothermia across the whole range of chamber temperatures employed. At 12C the fall in rectal temperature in wetted birds was 3.03±1.75C, an additional decrease of 2.1C compared to the corresponding "dry" group.

In wetted birds the relationship between the change in rectal temperature (T_r) and T_e could be described by $y = -0.692x + 10.39$ ($p<0.001$). Marked hypothermia was therefore induced at all other chamber temperatures and ranged from a reduction of 4.4±3.25C at T_e=8C to a maximum and life threatening fall of 14.2±5.37C when T_e= -4C. A lethal body temperature of 24C has been reported in the fowl (Freeman 1971) although mortality may increase if core temperature (T_r) falls to 32C. Wetting of animal coats and penetration by air movement are known to substantially reduce insulation effectiveness by at least 50% and to increase heat transfer (MacArthur 1987b). In the present study such compromise of feather insulation coupled to enhance direct evaporative/convective cooling in the wetted birds may clearly impose heat losses upon the bird which cannot be met by other physiological and metabolic adjustments. The consequent moderate to severe hypothermia may reflect significant reductions in welfare and underlie increases in mortality in transit in cold, wet, winter weather.

Characterisation and effects of transport thermal micro-environments:

Three-dimensional thermal mapping (see figure 6.3.2.2.) on many journeys on commercial broiler transporters has revealed that distributions of both temperature and humidity (water vapour density) are heterogeneous within the transport space (Kettlewell and Mitchell 1993a & b; Mitchell and Kettlewell 1998). There are substantial increases in both variables over ambient conditions in parts of the vehicle. It is apparent that a heterogeneous distribution of heat loads exists with a gradient essentially from front to rear of the vehicle resulting in the existence of a "thermal core" towards the upper front central area of the vehicle. Thus both temperature and water vapour density are elevated towards the front upper area of the lorry and trailer and thus these locations are more likely to induce heat stress in birds in transit whilst much lower temperatures closer to ambient conditions will be encountered towards the rear of the vehicle components.

Legend 6.3.2.2 Spatial distributions of temperature (closed boxes) and vapour density (open boxes) on a passively ventilated broiler transport vehicle. The vehicle comprise two components, lorry and drawbar trailer.

On typical transporters temperature increases of 10-20°C in the thermal core may be encountered in closed vehicles. Thermal core temperatures of 25-26°C accompanied by water vapour densities of 5-17 gm-3 may be observed regularly on commercial transporters in the UK during winter transport when external temperatures may be 5-8°C. On such vehicles an 18°C gradient between thermal core and air inlet will exist with a parallel humidity gradient. Thus, the complex nature of the thermal micro-environment on broiler vehicles may result in a risk of severe heat stress in relatively mild weather conditions. Core temperatures of >30°C and vapour densities >20gm^{-3} have been reported in the UK (Kettlewell and Mitchell 1993). More recent studies (Knezacek *et al.* 2000) have further demonstrated the complexity of the "on-board" thermal micro-environment employing thermal mapping on commercial vehicles under extreme cold conditions. A 60°C temperature increase was reported in one container in a broiler transporter operating with minimal passive ventilation with an external temperature of -28°C in central Canada. The resulting thermal core temperature of 32°C would have resulted in a degree of “paradoxical heat stress” under extremely cold external weather conditions. Clearly the issues of elevated external temperatures are even more important in countries whose climate is sub-tropical or tropical including those European broiler producers bordering the Mediterranean.

The effects of exposure to high thermal loads in transport containers obviously include profound heat stress and increased mortality and thus major reductions in bird welfare. In production terms there are other important influences. For example heat stress will induce marked elevation of evaporative heat loss and thus body weight loss (Carlisle *et al.* 2003). This study included three separate but related experiments and quantified the components of water loss from broiler chickens (2 kg body weight) under a range of thermal environments. In the first, respiratory evaporative water loss was estimated gravimetrically for individual broiler chickens over a range of environmental temperatures from 24-36˚C. In the second, total weight loss was estimated in groups of broilers in commercial transport crates over a similar range of micro-environments. In the final phase weight change and evaporative water losses of broilers on a commercial transport journey were measured by means of pre and post-journey weighing of the load and determination of inlet and outlet water vapour density on a mechanically ventilated vehicle throughout the journey. Respiratory evaporative water loss increased from 0.77±0.19 g kg^{-1} hr^{-1} at 24ºC to 4.3 g kg^{-1} hr^{-1} at 36ºC ($p<0.001$) in individual birds which would equate to weight losses of 30-168 kg on a typical UK broiler transporter carrying 6500 bird on a 3 hour journey. Measurements of total weight of broilers over a range of temperatures from 20-30ºC on similar simulated journeys indicate losses of 0.87-2.2 g kg^{-1} hr^{-1} ($p<0.001$) which would result in weight reductions at the factory of 34-86 kg per load. Subsequent studies on commercial vehicles revealed actual weight losses of 4.6-6.6 g kg^{-1} hr^{-1} (mean 73 kg per load) under varying thermoneutral conditions chiefly attributable to the measured water vapour heat exchange.

Particular attention, therefore, must be paid to the transport and holding thermal micro-environments and the thermal loads imposed upon the birds including both dry bulb temperature and humidity. The consequences of elevated thermal loads for bird welfare and productivity are profound.

Factors determining the thermal micro-environment of poultry transporters:

The internal thermal micro-environment in the transport containers is the product of the inlet air temperature and humidity, airflow rate and the heat and moisture production of the birds (Mitchell *et al.* 2000). It may be suggested that the passive ventilation regimes of most commercial broiler transport vehicles result in low rates and heterogeneous distribution of airflow within the bio-load. Studies have characterized the pressure profiles over the surface of, and within, commercial broiler vehicles (Baker *et al.* 1996, Dalley *et al.* 1996, Hoxey *et al*, 1996). It is these pressures that drive passive ventilation within the vehicle.

A central feature is the tendency for air to move in the same direction as the motion of the vehicle, thus, air tends to enter at the rear and move forward over the birds exiting towards the front. This pattern, of course, accounts for the distribution of temperatures and humidities observed on commercial vehicles, the existence of the "thermal core", the ingress of water spray and bird wetting and the pattern of DOAs and thermal stress found within the load (Hunter *et al.* 1997, 2001;

Mitchell *et al.* 1997, 1998a). The importance of airflow direction and pattern has been emphasized by Mitchell and Kettlewell (2002) who reported work demonstrating temperature distributions at the rear (air inlet) of a passively ventilated, closed sided vehicle on a winter day. It was apparent that cold air (at velocities of up to 1.2 ms^{-1}) can penetrate the bio-load by up to 1.7m chilling birds in these locations and causing profound cold stress if accompanied by wetting (Mitchell *et al.* 1997; Hunter *et al.* 2001).

When vehicles are stationary there is no external force driving the ventilation and heat and moisture removal is dependent upon free convection. In this situation problems of heat stress may be markedly exacerbated even on open or semi-open vehicles particularly in hot and humid weather conditions. Whilst the heterogeneity of the thermal micro-environment is less on moving open-sided vehicles gradients of temperature and humidity still exist. On curtain or closed-sided vehicles the problems of elevated thermal loads and localized cold stress zones can be exacerbated. It is clear that the problems associated with thermal micro-environments are primarily a consequence of the inadequacy and poor distribution of the ventilation flow through the bio-load. Any practical solution to these problems must involve modification and improvement of the ventilation regime.

6.3.3. Effects of food and water deprivation

Because birds do not have access to food and water in transit they may become hungry and dehydrated. The latter is particularly likely with high ambient temperatures when large amounts of water may be lost through panting. Birds are also deprived of food, and to a degree, water before they are caught and crated. This is to partially empty their guts in the interest of improved hygiene at slaughter. Food deprivation leads to live weight loss, the rate being rather variable (see: Warriss *et al*, 1999b), and after long deprivation, carcass weight loss. It also reduces liver weight and glycogen levels in the liver and some muscles, (Warriss *et al*, 1988) which could induce feelings of fatigue (Warriss *et al*, 1993) although transported birds have nevertheless been observed to tend to be more active subsequently (Sherwin *et al*, 1993).

6.3.4. Preparation for Transport

Broilers: As mentioned above, birds are deprived of food, and sometimes water, before catching and crating. Reducing the contents of the gut relieves pressure on the intestines and minimizing leakage of contents if the gut is accidentally perforated during slaughter/dressing procedures (Warriss *et al*, 1999b). Food deprivation times from 4 to 10 hours have been recommended (Anon, 1965; Wabeck, 1972) but there is little or no definitive evidence for the value of different fasting times. There would appear to be no evidence that deprivation of water before crating is beneficial to ultimate meat hygiene.

To facilitate catching, while keeping the birds calm, the process takes place in conditions of very dim light, often at night or in the early morning. An important consideration relates to the suitability of birds to travel. A high proportion of commercial broilers show some degree of lameness caused by problems in the bones and joints of the legs (Julian, 1984; Kestin *et al.*, 1992; Kestin *et al*, 2001; Sanotra *et al.*, 2001). The aetiology and pathology of the condition have been reviewed by Bradshaw *et al.* (2002). Lameness is likely to be painful (McGeown *et al*, 1999; Danbury *et al*, 2000) and transport, and the handling associated with it, is likely to increase the suffering of these birds. The case of lame broiler chickens presents particular concerns with regard to their not being transported in order to avoid increased suffering.

6.3.5. Loading and unloading

(1) Broilers: The importance of careful handling is evidenced by differences in the amount of bruising in broilers harvested by different catching teams (Taylor and Helbacka, 1968), the implication being that some catchers are less skilled or less considerate than others. Birds should be lifted carefully. Ideally this should be by holding the body. However, it is more usual, if not universal, to catch and lift birds by their legs. Both legs should be used to lift the birds since this reduces the frequency and severity of haemorrhaging in the thigh (Wilson and Brunson 1968). It also reduces the number of broken bones sustained.

The use of mechanised catching for broilers has some advantages (Berry *et al*, 1990). Several types of mechanised systems have been proposed but only those that use sweeping mechanisms provided with soft rubber "fingers", usually mounted on vertically rotating rotors, have been successfully developed commercially. The fingers sweep the birds onto a conveyor belt that transfers them to the transport receptacles. Potential advantages of mechanised systems include reduced labour costs, obviation of human health problems associated with manual catching and improved animal welfare, specifically a reduction in bird stress and trauma. However, in practice it is unclear whether there are improvements in welfare, probably at least in part because the standard of care exercised in manual catching systems, with which the mechanised systems must be compared, varies considerably. There may also be differences between different designs of catching machines in the way that they collect and move the birds. Some designs might therefore be better than others in terms of welfare.

In a recent rather extensive German trial of a catching machine employing a three-rotor sweeper and conveyor system manufactured in Denmark, 40 manually caught loads (869,738 birds) were compared with 43 machine caught loads (1.112,419 birds) over a period of a year (Knierim and Gocke, 2003). Machine catching significantly reduced the prevalence of fresh bruises, leg and wing bone fractures, and bone dislocations, of all categories studied. The reduction in the number of bruises ranged from 23-31%, the reduction in the number of fractures ranged from 48-70%, and the reduction in the number of dislocations ranged from 20-50%. The number of birds with one or more injuries was significantly reduced from 4.38% in manually caught birds to 3.07% in machine caught birds.

Mortality (% DOAs) ranged from 0.23-0.69% in manually caught birds and from 0.31-0.76% in machine caught birds when sampled over the four seasons (autumn, winter, spring and summer). Only in spring was mortality significantly different between the catching systems, when it was higher for mechanically caught birds. Overall, mortality in manually caught birds tended ($p = 0.07$) to be lower (0.39%) than in machine caught birds (0.54%). However, some caution needs to be attached to this finding. Because the machine operated at a higher speed than manual catching, more birds were put into each transport container and the stocking density was correspondingly higher. This might have increased mortality. With the same stocking density mortality could have been similar for both methods.

The authors noted that the prevalence of injuries in mechanically caught birds significantly decreased with greater experience by the catching team in the machine's use; the same was not true for manually caught birds. The implication is that further reductions could be possible in the amount of live bird damage from the figures achieved in the study.

Schneider (2000) apparently studied the same birds as Knierim and Gocke (2003). She found that deaths in the mechanically caught birds were caused by heart failure, fractures, liver rupture, or haematomas in the spleen or kidneys. There were more deaths with faster speeds of the conveyor belt, probably because the higher speeds led to more birds than desirable being put into the transport receptacles. Stocking densities were therefore higher than after manual catching. This led to more DOAs caused by shock and hyperthermia. It was suggested that the increased level of bruising at lower stocking densities was caused by birds losing their balance during transport.

It is apparent that many factors are important in determining the relative value of different catching methods in terms of bird welfare. It appears to be sometimes difficult to make absolutely valid comparisons between very different methods. Particularly with new methods, it is important that the operatives are fully experienced in using them when they are compared with established techniques. On balance, mechanised systems for handling animals do have some inherent advantages. They remove the variation inevitable between operatives of different skill levels, they do not become tired or fatigued and they are more likely to operate at constant speeds. Moreover, they tend to reduce the animal's contact with humans. Animals often find being close to human beings stressful (For example, Duncan et al., 1986) found that heart rate was lower in birds handled by machines compared with birds handled manually. It therefore seems likely that mechanised catching systems are desirable from a welfare standpoint.

On arrival at the processing plant birds are unloaded into lairage. This is a covered area where they are held until moved to the slaughter line. Studies have demonstrated that lairage or holding micro-environments may be poorly controlled (Quinn *et al.* 1998) and in consequence hyperthermia or heat stress may occur during this period resulting in acid-base balance disturbances muscle damage and further reductions in bird welfare (Hunter *et al,* 1998). Warriss *et al*. (1999a) examined the effect of holding broiler chickens in their transport "modules" in lairage for up to 4 hours. The two most important consequences of longer times were that the bird's deep body temperature increased progressively, with the most rapid rate of increase occurring in the first hour, and that liver glycogen decreased after the first 1 or 2 hours in lairage. The implication of the progressive increase in body temperature is that the birds were unable to thermoregulate adequately to maintain their temperature constant under the conditions prevailing in the lairage. Generally, with longer time, the temperature and relative humidity of the air within the containers in which the birds were held tended to increase. Based on their findings the authors recommended that broilers should ideally be killed immediately on arrival at the plant with a maximum acceptable lairage time of 1 hour. Holding birds for longer would require the development of improved methods of ventilation of the modules.

(2) Culled hens: Careful handling is particularly important in hens because of the relative fragility of their bones. Gregory and Wilkins (1992) found that removal of hens from cages holding the birds by two legs compared with a single leg reduced the incidence of broken bones from about 13 to 5%.

The removal of hens from battery cages is difficult since these do not usually allow easy access. It is therefore important that the cage fronts are opened sufficiently and that the birds are removed carefully. Catching hens in "alternative" systems such as percheries is often made difficult by the furniture and structure associated with the perches and nest boxes, and the fact that birds have more opportunity to escape. Both cages and alternative systems should therefore be designed with bird depopulation in mind since easy catching is likely to be less stressful to the birds and result in less physical trauma.

6.3.6. Floor/space allowance

There appears to be little or no research on appropriate stocking densities for broilers or hens during transport. Canadian recommendations (Anon, 2001) are that, for growing and adult birds, the maximum density in "cold" weather as found in winter should be 63 kg/m². The stocking density in summer should be reduced from this value, although no specific reduction or density is specified. It is not clear whether these recommendations are based on research findings or on practical experience. New Zealand recommendations (Anon, 1994) are that poultry weighing less than 1.6 kg need 175 cm²/kg, those weighing 1 to 3 kg need 150 cm²/kg and those weighing 3 to 5 kg need 110 cm²/kg. It was recommended that these space allowances should be increased during summer, especially if the weather is hot or humid. Again, it is not clear whether these recommendations are based on research findings or on practical experience.

However, if the minimum space required by a bird is defined by the general equation:

$$\text{Area } (m^2) = 0.021 \text{ weight } (kg)^{0.67}$$

Then a bird weighing 2.0 kg needs 0.0334m^2, equivalent to a stocking density of 59.9 kg/m^2, and a bird weighing 2.5 kg needs 0.03889m^2, equivalent to a stocking density of 64.4 kg/m^2. The Canadian figure of 63 kg/m^2 thus corresponds reasonably well with maximum acceptable stocking densities predicted by theory, at least for "cold" weather conditions, and for birds weighing between 2 and 2.5 kg. For a bird weighing 1.5 kg the corresponding figures are 0.0275m^2 and 54.4 kg/m^2. The equivalent New Zealand figures are that a bird weighing 2.5 kg needs 0.0375m^2, one weighing 2 kg needs 0.0300 m^2 and one weighing 1.5 kg needs 0.0263 m^2. A summary of these floor space allowances for birds weighing 2 and 2.5 kg is given in the Table (6.3.6.1.) below:

Bird weight	System	Floor area (m^2)	Floor area (kg/m^2)
2 kg	Formula*	0.03341	59.85
	Canadian	0.03174	63
	New Zealand	0.03000	66.66
2.5 kg	Formula*	0.03889	64.4
	Canadian	0.03968	63
	New Zealand	0.03750	66.66

Table 6.3.6.1. * Area (m^2) = 0.021 weight (kg) $^{0.67}$

The current recommendations for transport stocking density for broilers as presented in EC 95/29 and WATO, 1997 are :-

Birds body weight	Space allowance
< 1.6 kg	180-200 $cm^2\ kg^{-1}$

>1.6 but <3.0 kg	160 $cm^2\ kg^{-1}$
>3.0 but < 5.0 kg	115 $cm^2\ kg^{-1}$
>5.0 kg	105 $cm^2\ kg^{-1}$

In the UK and many parts of the world the most commonly employed modular transport system for broilers is the “Anglia Autoflow” design. The transport containers or “crates” in this system have a floor area of 0.78 m^2

Thus as practical stocking density is 17-25 birds in commercial practice then assuming all bird sare 2.0 kg body weight then the range of space allowances is 43.6 - 65.8 kg m^{-2} or 229$cm^2\ kg^{-1}$ - 152$cm^2\ kg^{-1}$ and thus compliant with current regulations.

The New Zealand recommendations (Anon 1994) specify minimum container height requirements. For poultry weighing 1 to 4 kg this is 25cm.

As implied by the above recommendations, particularly in hot weather it is important to reduce the stocking density in the crates or module drawers to allow better air circulation and prevent the build up of heat and humidity. This can be illustrated by data from Warriss *et al*. (1992a) relating to the provisions made in one UK plant. Between March and August, when ambient temperatures would have increased considerably, stocking density was reduced progressively from 17.3 to 15.8 birds per transport crate. This was associated with a reduction in mortality from 0.22% to 0.16% despite the higher ambient temperatures probably experienced. The reduction in stocking rate corresponds to a decrease of 8.7% in stocking density.

There appear to be no specific recommendations for the height of transport containers, or scientific evidence on which to base these.

6.3.7. Vehicle design

(a) Birds' physiological requirements - optimum conditions and limits.

In order to improve poultry transport vehicle design it is essential to establish the optimum environmental conditions for carriage of the birds and the acceptable ranges and limits for the various components of the micro-environment to which the birds are exposed. This can be achieved by means of physiological modelling and subsequent validation of such models under commercial conditions. The data thus obtained can inform the design of improvements in vehicle design and transport practices, and are based upon matching of the transport environment to the birds' biological requirements.

The degree of physiological stress imposed upon slaughter weight broilers by a range of temperature humidity combinations has been determined in transport simulation studies (Mitchell and Kettlewell 1998; Mitchell *et al*, 2000, 2001). This approach may be termed "physiological stress response modelling". Appropriate physiological parameters were selected to allow assessment of thermoregulatory (homeostatic) success and effort, extent of activation of the hypothalamo-pituitary-adrenocortical axis (corticosterone secretion) and the degree of stress-induced myopathy induced in broilers over a range of thermal loads. The latter were expressed as Apparent Equivalent Temperature (AET) derived from dry bulb temperature, water vapour pressure and the corrected psychrometric constant (Mitchell *et al.* 1996a; Mitchell and Kettlewell 1998). This approach allowed definition of thermal comfort zones, optimum transport conditions and acceptable limits for temperature and humidity for broilers in transport crates under commercial transport conditions In essence it is recommended that temperature-humidity combinations yielding an AET of >65°C in transport containers should be avoided at all times as these thermal loads would be associated with severe thermal stress (danger zone) and increased mortality. In practice this equates to maintaining the "in-crate" dry bulb temperature at 26-27°C or less because of the usually encountered water vapour densities in commercial transport containers (70-80%). Temperatures and humidities equating with AET values of 40-65°C may impose mild to moderate physiological stress (alert) and those of <40°C may be considered to associated with minimal stress and are thus safe (Mitchell and Kettlewell 1998; Cockram and Mitchell 1999). The physiological modelling procedure provides the "target conditions" to be achieved by modification and improvement of vehicle ventilation.

(b) Strategies and solutions - improved ventilation

A number of modifications to existing passively ventilated vehicles may be made in order to improve air flow through the load space, however, the success of these strategies is limited particularly in the face of the hostile climatic conditions encountered in many major broiler producing regions. If current transport numbers per vehicle are to be maintained to ensure economic efficiency then forced or mechanical ventilation may be the only feasible option. In order to define the specifications of such a system it is necessary to determine three factors:

(1) The ranges and limits for temperature and humidity within the transport containers and the optimum thermal environment for transport.

(2) The acceptable temperature and humidity increases above ambient for a range of external conditions.

(3) The heat and moisture loads for dissipation by the ventilation system

Physiological response modelling has provided the data necessary for factors 1 and 2. Total heat and moisture productions of slaughter weight broiler chickens have been measured in a unique study in which a broiler transporter was instrumented to function as a "direct calorimeter" (Mitchell *et al.* 1998b; Kettlewell *et al.* 2000, 2001a). The steady state total heat and moisture production of broilers were measured on a fan ventilated commercial transporter. Temperature and water vapour densities were accurately determined at defined inlets and outlets on an otherwise sealed vehicle and sensible and latent heat losses calculated from precisely calibrated fan throughput. Measurements were made over a 2hour period on each of 6 days. The lorry carried birds of 1.75±0.06kg body weight. Ambient temperature (T_e) during the experiments ranged from 9-17C. Two fan flow rates (2.8 and 4.9 m^3s^{-1}) were employed. Mean total heat production on the lorry was 26.1±3.0 kW which could be partitioned into 63% sensible and 37% latent components. This value represents 9.5±1.0W per bird. In parallel transport simulation laboratory studies using similar birds (T_e = 20C) metabolic heat production determined by indirect calorimetry was 8.7±0.5W. This value is in close agreement with that determined in the "whole vehicle direct calorimeter" and with previously published total heat productions for broiler birds (Xin *et al.* 1996). On the vehicle water loss was 1.43mg per bird $^{-1}s^{-1}$ and it may thus be calculated that to maintain a specified temperature lift within the transport container the ventilation system must be capable of dissipating loads of at least 5.41Wkg^{-1} and 0.82$mg.kg^{-1}s^{-1}$. In practice removal of larger heat and water vapour loads may be required. Thermoneutral water productions of broilers as high as 1.8mg kg^{-1} s^{-1} (Xin *et al.* 1996) have been reported and this must be considered in the calculation of water vapour removal targets and rates. Deep body temperature measurements in broilers at the lorry air inlets and outlets indicated a slight cooling of the birds at both of the ventilation rates employed (-0.41±0.34C) suggesting at least adequate removal of heat and water vapour loads. It has thus been possible to calculate the ventilation flow rates required for operation in specified external environments from the following relationship:

$$VFR = TMHP / C_p \times \Delta T$$

Where VFR = Flow rate (m^3s^{-1})

TMHP = Total metabolic heat production (Js^{-1})C_p = Specific heat capacity of air (1226 $Jm^{-3}C^{-1}$)

ΔT = Acceptable rise in air temperature (C)

On the basis of these findings it is proposed that the effective ventilation rate for vehicles in this configuration, fully loaded and operating at environmental temperatures of up to 20C should be 0.6m^3s^{-1} per tonne live weight (Kettlewell *et al.* 2001a). Several fans should be installed on the vehicle giving a maximum ventilation rate that will exceed this value. Fans should be placed where air does not otherwise circulate. Fans should thus be located in areas of the vehicle where the surface pressure profiles are such as to maximise fan air extraction efficiency i.e. in areas of lowest surface pressure (Hoxey *et al.* 1996; Baker *et al.* 1996; Dalley *et al.* 1996). . Practical constraints upon fan location are imposed by the need to have easy access to the vehicle "load space" for loading and unloading. In practice therefore fan should be located in the front headboard and rear tailboard of the vehicle.

Fans are available which will achieve this and in practice much higher rates may be required in hot weather. It must be emphasized that removal of water vapour by the ventilation flow is of paramount importance in controlling the internal thermal micro-environment of the poultry transporters and it is therefore essential to calculate or measure both heat and moisture production of birds over a wide range of thermal conditions. These specifications have provided the basis for the design and development of fan ventilated commercial broiler transport vehicles (in collaboration with a commercial coachbuilder) in the UK (Kettlewell and Mitchell 2001a & b; Kettlewell *et al.* 2001a & b). The control strategy for the ventilation rate is based upon the physiological response models and measurements of inlet and outlet air temperatures. These vehicles are now operating successfully in commercial practice.

6.3.8. Animal Preparation

Weeks and Nicol (2000) have pointed out the potential effects of rearing experience on the response of birds to handling and transport. Breeds reared at least partially outdoors at low stocking densities are generally less fearful (Grigor *et al*., 1995a) and thus may cope better with the stress of catching and transport. There is some supporting evidence for this (Nicol, 1992) although it is unclear whether this is likely to be important under the relatively high stress of commercial handling. Prior experience of handling by humans may also reduce fear but the evidence for the benefits of this in practice is contradictory (Nicol, 1992; Jones, 1996; Grigor *et al*., 1995a; Reed *et al*., 1993).

6.3.9. Travel times

Because broilers held in crates or drawers cannot be effectively fed and watered during transport, journeys must be considerably shorter than for red meat species. Although marketing times of over 12 hours have been recorded in the UK (Warriss *et al*., 1990), much shorter times are to be recommended on various grounds. Mortality is increased progressively with longer transport times (Warriss *et al*., 1992a). These authors recorded the number of broilers dead on arrival (DOA) in a sample of 3.2 million birds transported in 1113 journeys to a poultry processing plant. Journey times ranged up to 9 hours with an overall average time of 3.3 hours. Total time, from the start of loading birds on to the vehicle to the completion of unloading at the processing plant, ranged up to 10 hours with an average of 4.2 hours. The overall mortality for all journeys was 0.194%. However, as journey time (and therefore total time) increased, so did mortality rate. In journeys lasting less than 4 hours the prevalence of dead birds was 0.16% while for longer journeys the incidence was 0.28%. In all journeys longer than 4 hours mortality was therefore on average 80% higher than in all journeys shorter than this.

Birds suffering painful traumatic injuries such as broken bones and dislocations, which are not uncommon, will suffer progressively more in longer journeys. Liver glycogen, which provides a ready source of metabolic fuel in the form of glucose, is very rapidly depleted after food withdrawal. Warriss *et al.* (1988) found depletion to negligible levels within 6 hours. Broilers transported 6 hours had only 43% the amount of glycogen in their livers compared with untransported birds (Warriss *et al.*, 1993).

6.3.10. Rest periods

Rest periods are impracticable and counterproductive for poultry since, as mentioned above, birds cannot realistically be offered food and water. Neither can they be effectively inspected by Veterinary Authorities because of their close confinement in the transport receptacles. Moreover, with current systems of passively ventilated transport vehicles, the reduction in airflow likely if vehicles stop without unloading the birds is likely to lead to an increase in temperature within certain parts of the load and possibly cause the development of hyperthermia in the birds.

6.3.11. Feeding and watering

As mentioned previously, because birds transported in crates or the drawers of modular systems, it is not practicable to feed and water them. This highlights the importance of short transport times and careful control of overall fasting times before slaughter such that a balance is struck between the requirements of slaughter hygiene and those for animal welfare.

7. TRANSPORT OF TURKEYS

7.1. Introduction

The market for special poultry meat is expanding rapidly. In particular the consumption of turkey meat products is growing faster than any other kind of meat. The reasons for this growth are the health image of the product, which is considered lean and rich in protein, the increased availability of further processed products and, last, but not least, the relatively low price of this type of meat (Uijttenboogaart 1999). World-wide the consumption of turkey meat has been doubled over the last ten years and is now concentrated in five countries, where 85% of the total production is consumed. With more than 50% the USA is the leading consumer, followed by France, Italy, Great Britain and Germany. It is estimated that about 7 million turkeys are kept in Germany for commercial reasons. A total of about 30 million turkeys are produced per year. The UK consumption of turkey meat was estimated to be about 5.2 kg per capita per year in 1998.

7.2. Origin and domestication of turkeys

Studies regarding the origin of the turkey suggest rather conclusively that its native land was North and Central America and that it was probably domesticated in Mexico in prehistoric times. The more recent findings indicate there were, though now extinct, predecessors to *Meleagris gallopavo*, the progenitor of today's commercial turkey. Archaeological, biochemical, osteological, taxonomic and hybridization investigations provide evidence for distinctness of the *Phasianidae* family from other families within the order

Galliformes and from other avian orders. Varieties of turkeys, denoted by variations in pigmentation of feathers, appeared spontaneously and were recognized during the nineteenth century (Buss 1989) It was imported to Europe soon after the early exploratory journeys to North and Central America, reaching Britain about 1525 (Thompson 1964). There are several varieties (e.g. Norfolk Black, Bronze, White) and a number of commercial hybrids selected for increased meat yield, particularly from the breast muscles. The wild turkey is compared to the domesticated form smaller, the male turkeys reach a weight of about 5 kg and the females about 3 kg (Gigas 1987). Weights of over 11 kg are very seldom in wild turkeys (Grzimek 1969).

7.3. Diseases typical in Turkeys

Turkeys are susceptible to most typical poultry diseases. Therefore there is a risk that some of the commoner infectious diseases such as fowl pox, Newcastle disease, avian influenza, turkey rhinotracheitis, chlamydiosis, avian Mycoplasma infections might be transmitted as a result of transport. Experience in practice shows that transport stress can cause and enhance shedding of infectious agents such as salmonella from latently infected birds. Precaution should be taken that turkey transports are not passing closely along breeding farms to prevent transmission of diseases.

Turkeys can suffer from aorta rupture during transport caused by high blood pressure under transport stress

Gentle loading, transport and handling can reduce the risk of disease spreading, losses and suffering.

Production diseases

Turkeys on farms may be affected by feather pecking, cannibalism, skeletal abnormalities, cartilaginous emboli in the spinal cord, or aneurisms (Stedman et al. 1998). Any of them could significantly affect welfare during transport.

7.4. Housing and handling on Farms

The modern poultry industry developed rapidly in the second half of the twentieth century, though the roots go back to Roman times. Up to the second world war turkeys were extensively reared in a traditional way, that is running free with seasonal breeding and natural as well as artificial hatching. The birds were slaughtered in the late autumn or in the early wintertime. After 1945 a very productive turkey industry developed with intensive housing conditions and whole year slaughtering. It developed progressively from numerous small flocks of dual purpose breeds scavenging around the barnyard, fed on scraps and home grown grains, and using natural lighting, incubation and brooding.

At the same time an intense development took place in the breeding area and within decades the domesticated turkey changed more than it did in centuries of domestication (Zylla-Bluhm 1993). One of the most important breeding results was the breeding of the wide breasted turkey with the hypertrophy of the breast- and leg muscles (Crawford 1984). The wild ancestors and relatives of domestic poultry include both temperate and tropical species. In common with other animals, the temperate species are more seasonal in their breeding, because chicks born in the autumn or winter would not survive. Seasonality is a disadvantage under domestic conditions, but the sensitivity of poultry to certain seasonal changes has been exploited to increase production. This has been achieved by controlling light conditions (Appleby et al. 1992).

Turkey poults are sometimes reared in tier brooders, and then moved to littered pen at three weeks of age, where they are kept on littered floors in very large houses of more than 10,000 birds. The best litter is softwood shavings provided fresh for each flock. To reduce material and labour costs efforts have been made to develop suitable non-litter surfaces such as wire mesh or slats, but with limited success. A number of attempts have been made to house broilers in various types of multi-bird cage systems in order to simplify management, improve environmental control and reduce the cost of litter provision and disposal. These attempts have not been entirely successful, mainly because broilers in cages spend much of their time resting on their keels on the floor and from the localized pressure develop breast blisters which result in carcass downgrading. Cushioned floors, where a rubber or plastic overlay covers the wire mesh, reduce this problem.

7.5. Transportation and Journey Management

7.5.1. General Aspects of transport

Turkeys are transported after hatching in controlled climate vehicles to the farms where they are kept for the first weeks in heated animal houses or houses with spot heaters. After 6 to 8 weeks when the thermoregulation of the birds is sufficiently developed they are driven to finishing buildings on the same farm or on other farms. At the end of the fattening period the turkeys reach weights between 12 kg (hens after about 20 weeks) and 22 kg (male birds after 24 weeks). For loading the heavy birds technical devices such as lifts and conveyors are increasingly used to lift the animals on the different decks of the lorries, to reduce stress of handling and the work load for the personnel.

The birds may be exposed to a variety of potential stressors during transit, including the thermal demands of the transport microenvironment, acceleration, vibration, motion, impacts, fasting, withdrawal of water, social disruption and noise (Mitchell and Kettlewell 1998) The adverse effects of these factors and their combinations may range from mild discomfort and aversion to death. Indeed, so Mitchell and Kettlewell (1998) state “studies in the U.K. have indicated that up to 40% of “dead on arrivals” (of broiler chickens) are attributed to “transport stress” and that mortality increases with journey length”. Figures for losses during transport of day-old turkey chicks as well as finished turkeys are rare. Drawer (1980) gives the figure for turkeys going to slaughter of “below 1%” which died during transport depending on the length of the journey. Day-old turkey chicks should not be transported much longer than 48 hours (Hamsic et al. 2003).

7.5.2. Transportation / Journey management

During transport excitement, pain, or suffering can occur. Waiting conditions can render the animals vulnerable to severe weather conditions. During hot and humid weather, transport can reduce problems. Any avoidable pain, suffering, excitement, or injury is to be prevented.

7.6. Transport of day-old turkeys poults

Turkeys first experience transportation, as newly hatched chicks, when they are taken from the hatchery to the rearing unit. The transport of day-old chicks poses few problems on short journeys because they are small and they have yolk sac reserves. They are usually transferred by hand from the incubator to lightweight, disposable containers with ventilation holes. Newly hatched chicks are not provided with food and water until they reach the rearing unit. During transportation, which may last up to two days on international journeys, chicks are completely reliant on yolk sac metabolism. In the directive on the protection of animals during transportation in containers issued on December 20, 1988 is regulated, among other things that chicks (of hens, guinea fowl, pheasants, ducks, geese and turkeys) are allowed to be transported up to 72 hours without water or feed supply. This time span seems to be too long for modern breeds of fattening poultry, including turkeys. Warriss et al. (1992b) found that chicks deprived of food and water for 48 hours weighed 16.5 g less than control chicks which had access to food and water within 6 hours of hatching. They showed both physiological and behavioural signs of dehydration and thirst. Hackl and Kaleta (1997) found that already from the second day of life of chicks of hybrid fattening hens without feed or water mortality begins and consequently, the (still) permissible maximum transportation time of 72 hours should never be reached. For broiler chicks the maximum transportation time was again found to be approximately 48 hours. Any transportation over that time causes severe problems. The same is true for newly hatched turkey chicks.

Hamsic et al. (2003) examined the rates of survival of turkey poults deprived of food and water between 72 and 48 hours post hatching. The investigation included a total of 600 turkey poults of the hybrid line BIG 6. The investigations comprise six separate trials using 50 female and 50 male poults in each of the experimental set-ups. The resulting data indicate that fattening turkey poults do not withstand a period of deprivation of 72 hours post hatch without increased mortality. After a period of 72 hours without water and food, a total of 30 of 50 male poults and 13 of 50 females died on the third to fifth day of life. Following a period of 60 hours of food and water deprivation 9 of 50 male poults and none of the female poults died. Subsequently, the period of food and water deprivation was reduced to 48 hours. In this experiment 5 of 100 male and 7 of 100 female poults succumbed. They concluded that post hatching turkey poults of this breed should not be deprived of food or water for longer than 48 hours. Adverse environmental conditions can exacerbate problems for the poults.

Carver et al. (2002) carried out a study to find causes for early turkey poult mortality. They found that the causes are multi-factorial, season, strain, breeder hen age, and hatchery significantly affect poult mortality. Hatchery-related risk factors for hen flock mortality identified in this observational study included truck on which poults were shipped, truck temperature, and number of poults dead on arrival at the farm. Hen flocks shipped in trucks with lower temperatures had higher odds of mortality on arrival. Hen flocks with higher numbers of poults dead on arrival at the farm had higher odds of mortality within the first 14 days after placement in the barn. Hatchery-related risk factors for tom flocks included desnooding, truck on which poults were shipped, truck temperature, shipping time, and weather conditions at placement. Tom flocks shipped on trucks with higher temperatures and / or increased shipping times had higher odds of mortality on arrival and within the first 14 days. Tom flocks placed during icy weather had lower odds of mortality, and those placed during cloudy weather conditions had higher odds of mortality. These observations show the importance of careful planning of transport and adequate ventilation and air conditioning on truck. Inadequate transport conditions of day-old chickens influence mortality rates and welfare of the growing flock. On arrival the chicks may be gently tipped out or removed manually.

7.6.1. Preparation for transport to slaughter

For hygienic reasons, turkeys usually are not fed for several hours before transport in order to facilitate digestive tract clearance before processing and reduce the faecal contamination of carcass and processed products. The withdrawal period if too long, will limit losses of live weight and carcass yield. It seems that about 6 hours are sufficient to clear the digestive tract (Baroli et al. 1999). Taubert et al. (2002) emphasise that food withdrawal for more than 13 hours before slaughter should be avoided since the reduced glycogen reserves in the breast muscle favour higher final pH-values in that retail chop. The length of the time of feed withdrawal should be carefully planned according to the catching, transport and holding time before processing.

7.6.2. Loading systems

Prescott et al. (2000) found that during loading, turkeys may suffer death, bruising, broken bones, torn skin and other physiological stress. The handling of poultry has been widely discussed and studied for laying hens and broiler fowl (Kettlewell and Turner 1985, Scott 1993, Knowles and Wilkins 1998) with sophisticated handling systems currently available (for example the mechanical poultry collector (Berry et al. 1990). This collector is not suitable for turkeys, but was the starting point of the development of gently working, reliable and efficient collecting devices (Knierim and Gocke, 2003; Gocke, 2000). In the turkey meat industry, only lately a greater range of handling systems has become available. Prescott et al. (2000) have investigated four designs of modular turkey transportation systems available in the UK and compared them in terms of carcass damage and heart rate during loading. Three of the four Systems (A, B and C) required turkeys to be manually loaded. The fourth System (D) was loaded by driving turkeys into it. Systems A, B, and C, compared in a balanced experimental design, had similar levels of fractures and bruising combined but variation in the types of damage. Birds from System D, which was examined outside the balanced design, showed much less damage than those from the other systems. Heart rate was lower for birds loaded into System D than for birds in the other systems, which all showed a similar high heart rate associated with loading. This pilot trial indicates that the adoption of System D could yield significant improvement to carcass condition and turkey welfare.

7.6.3. Transportation time

Löliger and Torges (1977) report losses of turkeys in relation to the transport distance and season. The highest losses (0.93%) are seen in January and February on journeys of more than 500 km. Journeys between 100 and 300 km displayed losses of 0.54%. On shorter journeys the losses came to 0.31%. In summer time (June and July) the losses were only about half of that in winter time. These findings and many experiences in practice emphasise that draughty, cool and wet conditions, as well as high temperatures in hot weather situations on the transport vehicles, cause very poor welfare. In very hot situations losses reached 1.63% on one transport. The crucial importance of a functioning ventilation system was emphasised by Bröcker (1977).

Transportation is usually carried out on specially constructed lorries. Transportation times can vary at times but is usually between 2 and 12 hours. With the decrease of the number of slaughter houses there is a tendency to longer journeys. A transport time of 3 hours may cause stress to the animals and accelerate the metabolism to a point of depletion of muscle glycogen, resulting in high muscle pH. On the other hand it seems that transportation for three hours and immediate slaughter after the transport does not negatively affect turkey meat (Owens and Sams, 2000).

Again taking meat quality as an indicator for the degree of stress Van Hoof (1979) states that transportation over long distances had no detrimental effect on the physiological condition of breast muscle, and the course of post-mortem breakdown of glycogen and adenosine triphosphate was quite normal, provided that the birds were properly handled and stunned without any delay after they had arrived at the abattoir. Resting the birds for a longer period (up to 24 hours) after transport may lead to further ante-mortem depletion of muscle glycogen and thus to an increase of the ultimate pH and should therefore be avoided.

Van Hoof (1979) also states that the physiological level of glycogen and ATP was not significantly affected by road transportation covering 260 km.

Taubert et al. (2002) carried out a study about the relationship between external stress factors and meat quality of turkeys and conclude that the results of this investigation indicate that transport distance influences the rate of glycolysis less compared to the total duration of the turkey's stay in the transport cages.

The results of the various reports show that journey times longer than 4 h increase mortality. Hot weather can increase mortality significantly but also in winter heavy losses can occur. The conditions on the lorries are closely related to animal density both in summer and in winter and the efficiency of the ventilation system.

7.6.4. Space allowance

In the countries of the EU the space allowance for turkey is restricted according to the body weight, small birds need a greater surface per kilogram of body weight than the larger birds. Depending on the body weight, between 90 kg/sqm (turkeys from 3-5 kg) and 100 kg/sqm (turkeys from 13-16 kg) are recommended. The deck height ranges between 25 cm and 35 cm, depending on age and weight but there appear to have been no studies in which the effect of height on welfare has been investigated. Ellerbrock and Knierim (2002) investigated the static space requirements of male meat turkeys and the area covered by them standing was measured by planimetry on photographs taken from directly above the birds. The birds were between 11 and 21 weeks of age. They found that there was a strong relationship ($r = 0.86$) between their live weight and the area covered, and a formula was derived for the calculation of the area covered by turkeys weighing between 7-6 and 21 kg. The coefficient derived from the measurements of this study: area (m^2) = 0.0252 x live weight $(kg)^{0.67}$. A comparison with the formula developed on theoretical grounds in 1995 by the Farm Animal Welfare Council (FAWC) showed that for heavy turkeys the FAWC formula is not valid, because it yields values which are about 50 per cent too low. The FAWC (1995a) gives the following formula for the calculation of the area required by a standing turkey in contact with other birds on all sides: area (m^2) = 0.021 x live weight $(kg)^{0.67}$. However this formula was developed solely on theoretical grounds and no further explanation was given for the derivation of the coefficient, apart from the information that a 5 kg bird was taken as the basis. The areas covered by the turkeys weighing 7-6 to 21 kg and aged 11 to 21 weeks ranged between 869 cm^2 and 1958 cm^2 , corresponding to animal densities of 78 kg per m^2 and 107 kg/m^2, respectively (Ellerbrock and Knierim 2002).

7.6.5. Microclimate throughout transportation

Turkeys, being used to a steady temperature are vulnerable to thermal stress, high temperatures as well as cold stress, even though heat stress and cold stress affect these birds in a different manner. A cool pre-slaughter environment seems to produce meat with better carcass quality characteristics and less PSE-meat, if the meat quality is taken as an indicator for stress (Babji et al. 1982). Froning et al. (1978) state that marketing turkeys during cold periods of the year may be less of a risk than marketing during hot seasons. So, in the hot summer season, the problem of high stocking density is greater than in the colder months. However, there are also reports about dead losses in winter time when the animals situated close to the edges of the lorry are wetted by rain and spray water at outside temperatures close to 0C. Also it is important to consider the ventilation of the truck and the length of the journey. The ventilation and the temperature should always be checked and if necessary be regulated. Up to 20C, conductive and radiative heat exchanges during a journey will be fairly constant for dry birds. Sensible heat loss will depend mainly on air temperature and the rate of air flow around the birds. Evaporative loss also depends on these two variables. High temperatures are often associated with reduced ventilation rate and thus high humidity. Transit times during hot weather must be minimized to prevent fatal dehydration and hyperthermia.

There is a thermal comfort zone, in which a bird is thermally comfortable and able to maintain its body temperature with little effort. Webster et al. (1993) were able to predict thermal comfort zones for conditions of low air movement and high humidity (typical in transit). The comfort zones are 8-18C for well-feathered birds and 24-28C for poorly-feathered birds. Increased air movement would elevate both the upper and lower limits of these ranges.

Since turkeys lose some feather cover due to pecking and plucking it seems obvious that with a decrease of feathering, the insulation of the body shell decreases and the heat loss increases. Nichelmann et al. (1986) carried out a study on the influence of feather cover on heat balance in laying hens (*Gallus gallus*) and found that in the case of defective feathering and increasing wind speed a change in the ambient temperature of 1 K leads to the same change in heat production as a change of 3 K in well-feathered hens living in a wind speed of 0.2 m/s. Thus a temperature change of 1K under conditions of increased wind speed and complete loss of feather cover are identical to an "effective ambient temperature" (EAT) change of 3.0 K. They also showed that for example the heat production of unfeathered hens at 40C is as high as that of those with complete feathering at 9C. So, the overall condition of the bird's plumage is of great importance in terms of the climatic situation on transports. However, there are some more factors such as age, wind speed and relative humidity which influences the non-evaporative and evaporative heat loss of turkeys as explained in the mathematical equation of Jurkschat et al. (1986).

The degree of thermal stress experienced by birds in transit depends on the duration and intensity of heat and cold stressors. The numerous variables associated with animal transport make it difficult to quantify thermal stress experienced by the birds and difficult to design transporters and warning systems to minimize such stress. In hot weather transporters should be stocked less densely and leave a row of crates empty. Side curtains are used as protection against precipitation, wind, solar radiation and increasingly to hide the birds from public view. However, even in winter, curtains often restrict ventilation and excessive heat and moisture levels build up around the birds.

Therefore, efficient ventilation is crucial for the welfare and health of turkeys on transport vehicles in winter and in summer. Experiences in the Netherlands show that the ventilation rate in turkey barns should be twice of that in broiler houses. Tüller (1997) recommends 5 to 7 m^3/kg body mass and hour in turkey barns to prevent heat stress. Most important is that the enthalpy of the air around the animals does not exceed 67 kJ per kg of dry air, values higher than 72 kJ are fatal (Guidelines to prevent heat stress in turkey barns, Ministry of Agriculture, Fisheries and Food, Lower Saxony). It seems that it may be useful to work along these empirical figures to elaborate recommendations for the micro-climate on turkey transporters, for summer conditions in particular. Such threshold values will be also helpful for the design of waiting conditions on lorries at the abattoir. Specially ventilated waiting halls or areas help to lower the temperature stress of the birds.

Waiting conditions on the lorry can render the animals vulnerable to severe weather conditions. During hot and humid weather driving can reduce heat problems by forcing the air flow in the lorry.

7.7. Post-transport handling

7.7.1. Resting time before slaughter

Van Hoof (1979) found that birds which rested for 24 hrs following transportation had lower glycogen and ATP levels at the moment of slaughter than non-rested birds. He also states that application of a proper stunning procedure was highly effective in preventing peri- and post-mortem muscle stress reactions. The use of low light conditions during the waiting time before slaughter reduces stress and further feed withdrawal for the bird (Uijttenboogaart 1999).

7.7.2. Carcass damage

Downgrading of turkey carcasses reduces carcass value, especially when whole carcass turkeys are in demand. Turkeys must have an intact carcass free of blemishes and unsightly lesions to qualify for Grade A. Conditions such as bruising, skin tearing, skin infections or ulcers, severe scratches, fractures of legs or wings, and other defects require the removal of affected parts, and therefore, reduce the grade.

Although little work on the damage inflicted on turkeys during handling, transport, and unloading has been done, a Canadian study (McEwen and Barbut 1992) did find high rates of carcass damage among turkeys. For example, 10% of turkey toms had bruised legs. Turkeys of today are more susceptible to injury during handling than was true of their counterparts of several years ago, mainly because they are generally heavier, younger, and softer muscled (Barbut et al. 1990). The reports about turkey downgrading because of bruising (blood in the tissue caused by trauma) and injury are influenced by such factors as raising the drinking and feeding equipment prior to catching, the driving or catching operation, loading the birds into the crates, transport to the processing plant, length of time on the truck, unloading, hanging on the shackles and flapping of the birds while on the shackles (Barbut et al. 1990). It is suggested that about 80% of the bruising takes place within the last 12 to 24 hours of the birds lives (Goodwin 1986, Wesley 1986b, Hamdy et al. 1961). Any level of damage is not only a potential welfare threat but also can represent a financial penalty through downgrading and wastage, particularly for damage to the valuable breast area of the bird. It is estimated that downgrades from broken bones, strained joints, tears, cuts, haemorrhages and disease conditions cost the U.S. broiler and turkey industry more than 90 million US-dollars per year (Wesley 1986a).

Stress has also been implicated in producing a pale, soft and exudative (PSE) condition of turkey meat (Sosnicki et al. 1998).

Barbut et al. (1990) underline the importance of the careful maintenance of the trucks and the smooth organisation to make sure that the birds are unloaded as quick as possible for stunning. Long hanging periods upside down after shackling which can last for up to 6 minutes are the main reason for high incidence of bruising.

Main deaths are due to chronic heart muscle diseases and liver failure (e.g. Löliger and Torges 1977).

7.7.3. PSE meat in turkeys

The occurrence and economic importance of the PSE condition in poultry meat have been the subjects of few investigations. Studies dating back to the 1970s have indicated that stress and variations among birds can contribute to differences in the rate of post-mortem glycolysis. In these early studies, the researchers suggested that “turkey breast muscle is susceptible to a PSE-like condition described in pork" (Van Hoof 1979) and "that pre-slaughter stress and struggle may affect the colour and textural characteristics of turkey meat" (Froning et al. 1978). Barbut (1996) found that 19% of the birds in his study would be classified as PSE-meat. He mentions that "overall, the study provided estimates of the PSE problem in commercial young turkey flocks and demonstrated the variation among flocks."

McKee and Sams (1997) studied the occurrence of PSE-meat in heat-stressed turkeys, since heat stress is one of the prominent ante-mortem stressors that elicits pale, soft, and exudative meat characteristics in stress-susceptible pigs. They found that the heat-stressed birds exhibited a faster pH decline and had higher R-values (R-value is an indirect measure of ATP depletion in the muscle; during rigor mortis development ATP in the muscle is depleted and the R-value increases.) that persisted through 24 h. The birds were also paler in colour and exhibited increased drip loss and cook loss when compared to controls. In addition, the heat-stressed birds had a higher frequency of abnormal birds than controls when birds were grouped as normal or abnormal.

Owens et al. (2000 a) carried out a study to evaluate the ability of halothane to identify stress-susceptible turkeys prone to developing PSE meat when reared to market age and transported before slaughter. They found that approximately 3.5% of the turkeys were sensitive to halothane at the age of 4 weeks. At the age of 20 weeks the halothane sensitive and the same number of halothane non-responders were transported in coops on a flatbed trailer for 2 hours and then immediately slaughtered upon arrival at the processing plant. There were no significant mean differences in any parameter measured between the two groups. These results suggest that either halothane response is only a limited predictor of PSE meat in turkeys or that transportation is not an appropriate stressor to induce the PSE condition. In another study carried out by Owens et al. (2000 b) two lines of turkeys, one selected for rapid overall growth and the other for large breast muscle yield, to evaluate the ability of halothane screening to identify stress-susceptible birds prone to developing PSE-meat when reared to marked age. Their results suggest that halothane sensitivity early in life is associated with heat stress susceptibility and the development of pale meat when birds are slaughtered at market age, they also suggest that halothane screening may be better at predicting the development of PSE meat during heat stress in the strain selected for large breast yield rather than rapid overall growth.

8. TRANSPORT OF DUCKS, GEESE, PIGEONS AND QUAIL

8.1. Introduction

Ducks, geese, pigeons and quail are increasingly accepted by consumers worldwide. Duck production in particular has risen in recent years. It is estimated that about 2 million ducks, both Beijing-ducks and Muscovy-ducks and 0.6 million geese are kept, e.g. in Germany, for commercial reasons. Considering these facts it is astonishing that there is relatively little literature on the transport of these birds.

8.2. Ducks and Geese

Origin and domestication

All domestic ducks, except the Muscovy, are descended from the wild mallard (*Anas platyrhynchos*), are given the same Latin name and were first domesticated in Southeast Asia or China at a very early date. Eighteen breeds are recognised in the UK and fourteen in America (American Poultry Association 1989), varying in size from the Appleyard Bantam at 700 g to the Aylesbury at 4.6 kg, with some commercial hybrids weighing up to 8 kg. Most ducks are kept for meat production but some, such as the Khaki Campbell and Indian Runner, are extremely prolific egg layers.

The Muscovy (*Cairina moschata*) originated in South America, the domesticated form being similar to, but larger than, the wild species. Being of tropical rather than Palaearctic origin, it has a much lower body fat composition. Keeping in intensive commercial units is rather difficult because of high rates of feather pecking and cannibalism (Klemm et al., 1995).

Domestic geese are descended from the Greylag (*Anser anser*); again they were domesticated in China or Southeast Asia, probably earlier than the duck. They were well known in Europe by 700 BC, as they are mentioned by the Greek poet Homer. The Crested Goose was valued by the Romans for guarding duties and reputedly saved the Capitol from the Gauls in 390 BC by raising the alarm (Thompson 1964). Eleven breeds are listed by May and Hawksworth (1982) and by the American Poultry Association (1989).

Transportation

The capture, transportation and slaughter of ducks is much the same as other poultry, however research has indicated that they require a much stronger electric current to ensure a humane stun (www.animalsaustralia.org). They are slaughtered at around eight weeks of age. Carcass damage can occur when the ducks try to escape catching and run over the back of other animals causing scratches and injuries which reduces carcass quality. There are no scientific reports on optimal transport time. It is suggested that 4 h – similar to turkeys – seem to be an appropriate choice.

Stress-induced endogenous microbial contamination

Endogenous microbial contamination of slaughter animals can be induced by pre-mortem stress situations. Mengert et al. (1998) tested whether and to what extent pre-slaughter stress can lead to Muscovy ducks being endogenously contaminated. They observed the rate of contamination of the stressed Muskovy ducks (55.6%) to be significantly higher than the rate of the control group (23.2%). A connection between pre-slaughter stress and the level of bacterial contamination of the carcasses is inferred, with animal transport being the major stress factor in combination with thermal stress. Therefore it is necessary to stop feeding 8 to 10 h before transport. Usually fasting starts in the evening before the slaughter day. Loading and unloading happens mostly early in the morning before dawn. Nevertheless, that means that the animals are deprived of food for sometimes more than 12 to 14 h before slaughter.

8.3. Pigeons

Origin and Domestication

Domestic pigeons are derived from the rock dove (*Columba livia*) and have been domesticated for at least 5000 years. Images of pigeons dating from 3100 BC have been found in Egypt (Thompson 1964). They were originally kept for eating and only later were selected for their homing ability.

Housing

Pigeons are housed in pairs in shacks of about 10 to 20 pigeons. Outside the mating season male and female pigeons are separated into different shacks. Pigeons are also separated into groups of young pigeons (up to 10- 12 months) and old pigeons (over one year and having experienced at least one racing season.)

Transportation

Racing pigeons (*Columba livia*) participating in homing contests are transported from the home loft to the release site at a high stocking density. Dutch transport guidelines suggest transporting pigeons at a space allowance of 225 to 300 sqcm per bird (Gorssen and Koene 1997). Transport conditions are not only affected by high stocking densities but, since the racing season ranges from April to September, inadequate climatic control of the transport vehicle may put the pigeons at risk of heat exposure during summer. In addition, water deprivation for a period of 12 to 24 hours may occur (Gorssen et al. 1993). Marder (1983) noted increased aggression in heat-exposed pigeons. A combination of heat exposure and water deprivation results in dehydration of pigeons (Arad et al. 1987). In addition to that during transportation, the pigeons` behaviour might be affected by the motion, noise and vibration associated with a driving vehicle and during racing pigeon contests the time pigeons spend in a stationary truck with the engine off is considerable and this may also affect their behaviour (Gorssen and Koene 1997). These stationary periods include the waiting time before departure of the vehicle and especially the time between arrival at the release site and final release of the birds. Adverse weather conditions at the release site or between the release site and the home site often delay the moment of release by several hours or even days (Gorssen and Koene 1997).

Scope et al. (2002) carried out a study on the influence of stress from transport and handling on haematological and clinical chemistry blood measures in racing pigeons (*Columba livia domestica*). They found that stress has an influence on some blood variables in racing pigeons, though within 3 hr, most values did not exceed the reference ranges. The quality and extent of any changes are likely to depend on the severity, type, and duration of stressful events, like transport and handling. Assessment of these facts is difficult if not impossible and may differ in individual cases and, therefore, can hardly be standardised.

Gorssen et al. (1997) carried out a study on how water deprivation and thermal stress affect racing pigeons during transport. They concluded that 32°C is the upper critical temperature for pigeons housed under transport conditions. When pigeons have access to water (Gorssen et al. 1997), the variation in body weight loss within a group increases above the upper critical temperature. Water deprivation increases heat production, body weight loss, and dry matter content of the breast section at temperatures above the upper critical temperature. The resulting dehydrated state probably reduces the flying capacity of the pigeons. Hence, water deprivation and heat exposure during transport for homing contests may increase bird losses.

8.4. Quail

The Japanese quail is becoming an increasingly popular and important agricultural species world-wide. For example, egg production exceeds 18 billion a year in Japan and at least 2 million birds per week are slaughtered for the table in France. Quail farming is also growing in Britain.

Origin and Domestication

Two species of quail are kept: the Japanese quail (*Coturnix coturnix japonica*) which has been divergently selected for egg production on the one hand and meat yield on the other, and the bobwhite quail (*Colinus virginianus*) in America. The Japanese quail has assumed importance worldwide as a laboratory animal and is also commercially exploited for meat and egg production. In their intensively farmed conditions however, they suffer acute stress, attacking each other by pecking out feathers and sometimes eyes. Its distinct characteristics include fast growth, early sexual maturity, short generation interval, high rate of lay, and less fed and space requirements per bird than those for chicken. In their natural environment the wild and timid birds live amongst grasses and bushes. Small size, rapid growth and early onset of egg production enable quail enterprises to be established with a low capital outlay, and to start generating income quite quickly. Commercial quail farming is therefore becoming more popular and is being increasingly promoted in a number of Asian countries including Japan, China, North and South Korea, Hong Kong, Taiwan, Singapore and the Philippines (Itoh et al. 1981, Hertrampf 1987).

Transportation and slaughter

There is hardly any literature on the transport of quail.

Male Japanese quail are taken to be slaughtered by five weeks of age and females at six weeks of age, when they weight between 151 and 192g (Torges and Wegner 1984). Panda et al. (1987) found five weeks to be the ideal slaughter age for both male and female quail from the viewpoints of high economic return and meat palatability.

Jones et al. (1979) reported that feed withdrawal for 15 h prior to slaughter resulted in 10% reduction in body weight of *Coturnix* quail. Singh et al. (1980) found 8.4% and 7.0% weight loss in the live weights of the quail (both sexes) at five and eight weeks respectively following 12 h feed withdrawal before slaughter. Becker et al. (1985) withheld feed for 6, 12, 24 and 48 h prior to slaughter and reported 5.5, 9.3, 10.2 and 16.7% weight loss respectively in the live weight of 7-week-old male quail.

Equipment used for the processing of chickens could be reduced in scale to process quail. However, young quail have tender skin and fragile bones, necessitating careful handling to minimise processing damage (Panda and Singh 1990).

9. Transport of Ostrich and other ratites

9.1. Ostrich farming

In their regions of origin, sub-Saharan Africa, farming of ostriches has a long history, the first commercial production being undertaken in South Africa in the mid-nineteenth century (Stewart 1992; Batty 1994). Nowadays, ostrich farming is world-wide, currently being promoted in some European countries as alternative form of agriculture, with production of leather, feathers and meat (McKeegan and Deeming 1997). However, whilst there have been several studies on the behaviour of ostriches in the wild (Sauer and Sauer 1966; Bertram 1980; Bertram 1992; Berendsen 1995) little information on the welfare of ostriches in captivity is available. Few studies have been carried out in farming situations (Berendsen 1995; Lambert et al. 1995; Bubier et al. 1996; Degen et al. 1989; McKeegan and Deeming 1997; Deeming 1998; Deeming and Bubier 1999).

Ostriches are diurnal animals, most of the birds being mainly inactive at night (Deeming and Bubier 1999). Maintenance behaviours, such as yawning and stretching, usually take place after waking. Wild ostriches are gregarious animals, forming flexible groups of mixed gender and age, based on family units of 10 or more birds, characterised by a hierarchy headed by an adult male or 'major' female (Deeming and Bubier 1999). Sometime, family groups may join with others establishing large herds, where females usually occupy low rank positions.

Whilst ostriches are regarded as physically hardy birds, resistant to a range of environments, they are very social animals and relatively minor changes in their social structure or surroundings can result in stress related disorders (Stewart 1994). Stress induced behavioural changes may result in accompanying major physiological disturbances such as immune-suppression, nutrient malabsorption, diarrhoea, protein catabolism, weight loss, retarded growth, poor feather quality and reproductive suppression (Stewart, 1994). A major behavioural disorder is aberrant pecking, directed to the ground or objects, their own or group-mate feathers, toe and face, and even into the air (Berendsen 1995; Sambraus 1995; Bubier et al. 1996; Stewart 1994; Samson 1996). Whilst feather pecking is often described as "aggressive" (Samson, 1996) it may actually be part of the "functional system of eating behaviour" (Berendsen 1995; Sambraus 1995; 1996). Other frequently observed abnormal behaviours in ostriches of all ages are pacing, calling and disrupted sleep patterns and "pica" or "dietary indiscretion", which means the ingestion of objects or substances other than normal foodstuffs (Stewart, 1994; Samson, 1996). Ostriches commonly suffer impaction of the proventriculus and gastric stasis and perforation as a consequence of swallowing sharp or bulky objects. Stress is thought to be a major cause of pica and ingestion of foreign bodies will often occur after a change in the social or physical environment (Stewart, 1994; Deeming and Dick, 1995; Samson, 1996). Other reported aberrant behaviours include “stargazing” which presents as a partial opisthotonus, a retraction of the head or backward arching of the neck causing difficulties in feeding and drinking (Samson, 1996). Confinement stress seems to be the main cause of this behaviour and the absence of a more pathological basis can be confirmed by placing affected birds outside, the condition, and then rapidly disappears. Ratites are very sensitive to sound (SCECPAFP, 2003).

9.2. Isolation and mixing

Little is known about agonistic behaviour in farmed ostriches. Aggressive encounters have been recorded by adolescent males against females or by adults towards younger chicks (Deeming and Bubier, 1999). True aggression may be exhibited by farmed ostriches of all ages towards a stranger introduced into a group (Stewart, 1994). The aggressors may chase, kick and peck at the head of the alien bird and later the aggression may subside into threats including hissing and posturing. In a study on pecking behaviour in ostrich chicks (up to 5 weeks of age), pecking order and growth rate were negatively correlated and aggression was interpreted as an expression of misdirected feeding or pathological behaviour which prevented proper food intake (Lambert et al., 1995).

In general, ostriches tend to avoid contact with other animals, almost 75% of their interspecific behaviour being neutral. Rare agonistic encounters with other species are mainly due to defence (Deeming and Bubier, 1999). Ostriches raised on farms may be imprinted on humans.

Kamau et al., (2002) studied the effects of mixing and translocation of juvenile ostriches on the heterophil to lymphocyte ratio, as a consequence of glucocorticoid release or administration. A progressive increase of this ratio was observed after the application of these operations, changing from 0.27 and 0.37 on days 4 and 2, respectively, before mixing and translocation, to 0.53 and 0.84 on days 2 and 4, respectively, after translocation. The authors concluded that mixing and translocation of the ostriches led to stress, which may predispose to the development of impaction of the proventriculus. Since ostrich chicks are known to bond to people and other animals, Kamau et al., (2002) recommended maintaining together the same group of birds, as well as gradually introducing them to new environments and, as far as possible, maintaining the same personnel taking care of them. Similar advice for the management of rheas has been given (Frasnca and Khan, 1997). These management practices should be applied also for transport, where birds from different groups should not be mixed together (Wotton and Hewitt, 1999). Incidence of aggressive behaviour was shown to be correlated with the number of people involved into handling operations (Reiner et al., 1996). Therefore, it has been suggested that restricting the number of handlers would promote ostrich welfare, as well as involving their own stockman, since they become stressed by a change in routine (FACW, 1993; Wotton and Hewitt, 1999). Feed bucket training is easy in ostriches, and it may be of help in leading them into the transport vehicle (Wotton and Hewitt, 1999).

9.3. Pre-transport preparation and handling (loading and unloading)

The welfare of ostriches at handling is another area upon which little information is available. Few scientific studies have been undertaken to compare the stress-induced or welfare effects of different handling procedures or techniques (Reiner et al. 1996; Diverio et al. 2003). Clearly handling and transport are intimately linked and some general recommendations have been made (FAWC 1993; CE 1997). Adult ostriches are large animals but can be easily frightened and if allowed to panic and run at high speed they can suffer serious injury due to collision with fences, vehicles and other agricultural equipment. They also represent a serious hazard to the handlers.

Frequent handling of young birds leads them to become accustomed to human contact. Ostriches are easier to handle as a group than as individuals (Reiner et al. 1996), showing strong flocking behaviour, particularly when young, which can be useful when they are being loaded or unloaded (Wotton and Hewitt 1999). Small birds can be picked up whilst supporting the body. Raines (1998) recommended not to restrain young chicks only by legs or held upside down, but supporting them in a sternal position with legs tucked in the arm of the handler. For transport over long distances they can be wrapped in a towel secured with sticky tape. Chicks can be transported in dog crates provided with non-skid flooring or bedding (Raines, 1998). Juvenile chicks can be retrained by positioning their body between the handler's legs, holding the wing by the humerus, and the front of the bird by the breast plate (Raines 1998). These methods are in agreement with the recommendations reported in the Appendix 2 of SCECPAFP (2003), as technical details for the catching and handling ratites.

Ostriches may be loaded by driving on to vehicles if tame enough. However, many animals are captured and restrained by human handlers. Capture will always result in poor welfare but since it is widely used at present, details of methodology are presented here.

There are essentially three methods for capturing adult ostriches: while feeding, attracting them by food in a paddock or by the use of a hook. This device consists of an aluminium wire ring of 10-12 mm used to get hold of the neck of the ostrich (Veronesi et al., 2000). The hook is largely used because it makes capture easier and it allows a hood to be put over the head more rapidly. However, often this capture method implies excessive distress to the birds, because they have to be chased around in the paddock. In a comparative study of the stress response related to two different methods of capture (by hook or food attraction), transport and slaughter in farmed ostriches, the hook capture was shown to be the most aversive treatment (Diverio et al., 2003). In particular, hook captured ostriches compared with food attracted birds showed higher corticosterone, AST and a tendency to record higher ALT, LDH and CK activities, probably because of a greater physical exertion elicited by pursuit, escape attempts and prolonged capture times, (Diverio et al., 2003). According to Raines (1998) hooks should not be used, because of potential trauma to the ostrich's neck and head, such as high incidence of tracheal lacerations or death due to misapplication during capture. He suggested the use of ostrich chutes instead, or any kind of physical restraint devices, but the presence of an experienced handler and a smooth corner are essential for proper handling an adult bird (Raines, 1998).

SCECPAFP (2003) recommendations for capture of ratites reported that: "In general, guidance and approach should be from behind. However, when a shepherd's crook is used in selecting a mature bird from a group, this should be done from the front. The crook should be used to hook the bird around the neck just below the head, and to pull its head down to below back level. The bird can then be retrained by placing the thumb of one hand in the side of beak while holding the back of the bird's head low with the other hand. This will prevent the bird kicking forward. When catching and holding birds by the neck, great care must be taken to avoid damaging the neck. Birds should be prevented from moving backwards.

These findings agree with Veronesi et al. (2000), who suggested that the best way to capture ostriches is to entice them around the feeding trough, then grabbing the neck with one hand and immediately put a hood over their head. The animals can be attracted by their favourite food and then gathered in a long and narrow fenced-off area (not higher than 140-150cm) ending with a small triangular pen (about 1 m^2/head) enclosed with sturdy and attached boards. These must not have spaces in order to prevent the ostriches from getting their feet or wings caught in the spares thus injuring themselves or trying to climb up and escape (Veronesi et al., 2000). From here, a loading ramp surrounded by sturdy sides can give direct access to the means of transport (Veronesi et al., 2000). Hallam (1992) recommended the use of a central holding pen (10 x 20m), from where the birds could be herded in a squeeze pen and therefore driven as a group or restrained individually (Wotton and Hewitt, 1999).The recommendation of the SCECPAFP (2003) is always restraining adult birds by standing astride the back, holding its body with handler's legs placed between the wings, and with hands around the chest or base of the neck area. At least three people are required to restrain an adult animal (Veronesi et al., 2000).

Hooding the animals at capture is commonly used to facilitate handling and loading operations (Veronesi et al., 2000). Throwing a cloth hood over the ostrich's head, taking care not to obstruct the nostrils, makes animals easier to be handled, because it disorientates them, and induces a "freezing" response, characterised by extremely low heart rate. However, while hooding provides restraint, it may also significantly stress the birds (Crowther, 2001). Hooded ostriches are reluctant to move even if guided by handlers, probably because of a fear of falling (Crowther, 2001). Once moving, the ostriches' gait is usually unwieldy and similar to a rapid stomping action (Wotton and Lewitt 1999; Crowther, 2001). When ostriches refuse to move when hooded and restrained, two operators could load them by turning them around and backing them up (Raines, 1998). When ostriches are transported, the FAWC (1993) suggested removing all the hoods at the same time, before the departure of the vehicle. Similarly, SCECPAFP (2003) recommended that hoods should not be left on for longer than is absolutely necessary.

Handling and transport in low light may be beneficial, since darkness seems to have a calming effect on birds and encourages them to sit down reducing the impact of vibrations and movement (Wotton and Hewitt 1999; Crowther 2001). Adult ostriches can also be restrained by gripping the corner commissure of the mouth, but this, if excessive force is used, can severely injure the bird causing neck dislocation. Sometimes, repeated head shaking, which should disorient the animal, is used for restraining difficult birds, but this is not always effective (Wotton and Hewitt 1999).

The use of some tranquillizers, such as haloperidol, gave some positive preliminary results in reducing excitement during capture and sea transport in four adult ostriches, and it might be of use also for preventing stereotypical behaviours such as stargazing (Pfitzer and Lambrechts 2001). However, any necessity for use of such a drug is an indication that welfare is poor when the method of handling and management are used. Since this behaviour seems to be a consequence of stress and insufficient light (Samson 1996), it has been recommended that sufficient light should be provided during long-distance transport of ostriches (Pfitzer and Lambrechts 2001). This is in contrast with previous recommendations of transporting ostriches at night, since they respond well to totally darkened environments (Crowther 2001). Travelling in the dark seems also to eliminate the risk of ostriches eating the bedding, which may lead to proventricular impaction (Veronesi et al. 2000).

Loading ramps are commonly used for ostriches. However, since these birds will strongly resist loading when driven up steep ramps, loading preferably carried out on the level (no more than a 25° angle ramp) has been recommended (Payne, 1993). In MAFF (1997; 1998) recommendations it is indicated the used of a ramp angle not greater than 33°. However, both of these ramp angles are likely to cause problems for some birds which would not be caused by a level loading method or a ramp slope of 20° or less. In order to allow the passage of the bird and the three handlers, the loading ramp has to be at least 3m wide (Hallam, 1992), and provided with solid sides to preventing from falling off (Wotton and Hewitt, 1999). Ostriches can be led forwards up the ramp, or more commonly reversed backwards (Wotton and Hewitt, 1999). For unloading, covering the ramp and the ground with bedding material seems to encourage the birds to walk without too much hesitation (Bryden W., personal communication in Wotton and Hewitt 1999). They can be unloaded as a group or individually driven out after previous hooding (Wotton and Hewitt 1999).

9.4. Journey management

MAFF (1997) reported that “The Council of Europe document pointed out that ostriches, emu and rheas are ‘extremely susceptible to stress’ and that the prevention of stress in these birds is ‘of utmost importance’…” and made specific recommendations on a range of management procedures. However, despite the obvious importance of transportation of ostriches for relocation for breeding or rearing or to sites of slaughter little published information is available relating to the topic.

Vehicle design

Road transport of ostriches may be carried out on a number of vehicle types. Often modified cattle transporters may be employed divided into pens. In one study where juvenile birds were transported in this manner in pens (1.8 x 2.5m) containing 8 birds each, raised respiratory rates were noted accompanied by behavioural signs of distress, including neck twisting and other inappropriate behaviour (Payne 1993; 1994). The internal temperature at this time was 18C and relative humidity 89%. It may be proposed that the adverse reaction of the birds was a consequence of the loading procedures, the novelty of the environment and the imposed thermal load. In a recent study 50 ten month old ostriches were transported on a commercial vehicle, in pen groups of 10 individuals, for a period of 4.5 hours (Mitchell et al. 1996b). Despite a ventilation rate which maintained only a 1.0C lift over ambient in the transport compartment, physiological and metabolic measurements indicated that the birds experienced substantial stress during the journey. They exhibited depletion and utilisation of energy stores, dehydration, stress induced myopathy and marked activation of the hypothalamo-adenohypophyseal-adrenocortical axis. Concomitant video-recording of the ostriches behaviour throughout the journey revealed some unusual and aberrant behaviours, such head bobbing, arching of the neck and staring upwards (Mitchell and Kettlewell - unpublished results). The motion of the vehicle caused significant postural instability and sudden braking or accelerations caused disturbances and panic amongst the standing birds. Most birds attempted to stand throughout the journey. Another stimulus which seemed to influence behaviour was visual contact with the outside world and passing objects and vehicles clearly upset the birds. This was also true of humans approaching the vehicle when it was stationary (Mitchell et al. 1996b).

According to Veronesi et al., (2000), the best way of transporting ostriches aged around 4-5 months is on horse trailers, as they have a low loading board which facilitate loading/unloading operations, plus their low centre of gravity do not unbalance the animals. However, small horse trailers often have very poor suspension systems in relation to large, well-designed animal transport vehicles. Since ostriches are bipedal, with a high centre of gravity, particularly when adult, if they are not penned separately or have sufficient space to sit down, they may have to stand throughout the journey (Wotton and Hewitt, 1999; Mitchell et al., 1996b). In South Africa, the use of specific dividers is obligatory for emu transport, to facilitate loading and unloading (Veronesi et al., 2000). Individual penning is particularly suggested in case of adult mature males, young flighty birds or those with foot defect, but it should always allow them remaining in sight of other birds (Wotton and Hewitt, 1999).

Lorries specific for transporting a large number of ostriches are also available, characterised by a loading compartment split-up into individual divided parts using special transport crates (Veronesi et al., 2000). Lorries commonly used for other large animals can be adapted, where the loading ramp leads to the rear door, and the divider panels, hinged to one side, are opened and closed during the loading and unloading operations (Veronesi et al. 2000).

In South Africa, specially-built trailers with individual compartments are used for transporting 8 to 10 adult ostriches, whereas up to 24 birds can be transported over long distances in adapted stock lorries (Raines 1998). In any case, walls and floors are padded to prevent trauma, and air-conditioning is installed to keep birds cool (Raines 1998).

For transporting chicks up to few weeks old, it is necessary to prevent them from injuring themselves against the sides of the mean of transport (box) and to provide adequate bedding, since they may foul the floor with diarrhoea (Veronesi et al. 2000). It is more difficult with chicks older than three months, since they are too big to fit in a box and too small for a large vehicle.

Travel times (and road type)

According to MAFF (1998) and AATA Manual for the Transportation of Live Animals by Road 1996 (Harris, 1996), food and water should be provided on journeys lasting more than 12 hours. On long journeys if a vehicle carrying ostriches stops for 8 hours in any 24-hour period, preferably at night, the birds may be fed, watered and rested.

If breeder females are transported, there is the risk of internal trauma with consequent splitting of the egg inside the egg-tract (Veronesi et al., 2000). Furthermore, transport during spring or summer can cause other production losses, since distressed breeder females would not lay eggs for one or two months (Veronesi et al., 2000).

Veronesi et al., (2000) underlined the need to appropriately plan any ostrich transport. Short-distance journey may be carried out during the day-time, but for distances beyond 40-50 km evening or overnight is better, for both chicks and adults. This solution is the best in summer months.

Space allowance

Specific guidelines for the transport of ostriches are already available (DBV-SPCA, 1996; MAFF, 1998). According to them, space allowances should reflect age and size of the birds ranging from $0.1m^2$ for one month old birds to $0.75m^2$ for adults. However, these figures are not based on scientific studies of ostrich welfare. Chicks may be transported in groups of 4-6 per small crate compartment, because there is a danger of birds being smothered if kept in large groups (Wotton and Hewitt, 1999). Harris (1996) suggested that group sizes should be restricted to 8 up 12 birds per pen for juvenile (from 3 to 18 months) and of maximum seven in case of adult birds, since when overcrowded in large groups, they tend to clump into corners, with the risk of asphyxia or dislocation of the neck. No specific recommendations on stocking densities for the transport of chicks are available. Age group should not be mixed for transportation. According to Wotton and Hewitt (1999), to prevent ostriches being trampled or smothered, it's important that each bird has enough space to sit down, particularly if it is not individually penned.

Transport by air

Ostriches are frequently moved across continents by air and subsequently are transported by road over varying distances. It has been reported that on a long flight (6.5 hours) birds housed in purpose built wooden crates and with environmental temperature controlled to 18C generally "travelled well with no obvious ill effects" (Payne 1993; 1994). A degree of agitation and distress was apparent early in the flight in some birds and there was a risk of trauma as these individuals jumped around in the compartments. Each palate-sized crate (3.30 x 2.25 x 2.13m) was divided into 8 compartments each holding one bird. The space allowance per bird was thus $0.79m^2$ x 2m high. The thermostat for the animal hold was set at 18C and regulated by controlled ventilation. The temperature in the crates was maintained between 18-20C and relative humidity was generally kept below 50% (Payne 1993; 1994). This is important as high temperature-high humidity combinations are particularly damaging in animals relying upon evaporative cooling (Mitchell and Kettlewell, 1998). Under the controlled conditions, by employing low light levels, none of the birds exhibited signs of heat stress (Payne 1993; 1994).

Floor type

Large amounts of urine and viscous faeces can be excreted by ostriches, which can a form a slippery surface on the floor. Contrasting indications on different use and type of appropriate bedding inside the vehicle, according to the age of the birds, have been reported. In ostrich transport, sand and straw bedding are most commonly used, but whereas these seem to be suitable in adult birds, in chicks, as a consequence of the transport stress, there is the risk they consume large quantities of these bedding material (Wotton and Hewitt, 1999). In particular, the use of soft sand as bedding is no longer recommended in ostrich chicks since they have been found to ingest it. Otherwise, sand bedding can be used in adult birds, providing it is tick enough to adsorb their dropping during the journey (Wotton and Hewitt, 1999). Different indications have been given to the use of straw as bedding, for avoiding ingestion and preventing impaction: not to chop it (Wotton and Hewitt, 1999) or to short chop it as 30-50mm long (Mitchell M., personal communication). However, chopped straw should not be used for transporting chicks (Wotton and Hewitt, 1999).
Specific guidelines for bedding and fodder chop for housing ratites have been given (SCECPAFP, 2003), as follow reported:
"Bedding should preferably not be used for chicks under three weeks of age. If it is used it must be in small quantities."

Table 9.4.1.

Height of ratite	Size of bedding or fodder chop
< 30 cm	5 - 10 mm
30 – 45 cm	10 –15 mm
45 –60 cm	15 – 20 mm
60 – 77 cm	20 – 25 mm
75 cm – 1 m	25 –30 mm
1 – 1.5 m	30 –35 mm
> 1.5 m	35 – 50 mm

(from SCECPAFP, 2003).

Thermal conditions

The ostrich is obviously extremely well adapted to the climatic environments prevailing in the African regions, in which the species is indigenous and tolerates well hot arid conditions and cooler wet sub-tropical zones (Sauer and Sauer, 1966b). Stewart (1994) asserts that the birds are very hardy and "can be successfully bred and reared in environmental extremes from desert heat to winter snows". Ostriches, in contrast to most birds, have body temperatures below 40C and in the range of the eutherian mammals. The normal body temperature of the adult ostrich (body weight of up to 120 kg), measured in the rectum, is 38.3C (Whittow, 1976). The highest environmental temperature for thermo-neutrality is 20C (Skadhauge, 1981).
Ostriches exhibit a comprehensive repertoire of behavioural and physiological thermoregulatory strategies. During episodes of low environmental temperatures, to keep warm they bed down covering their legs with their wings to reduce heat loss and will alter piloerection (feather fluffing) to improve insulation (Stewart, 1994) and will shiver if body temperature starts to fall. However, ostriches can freeze to death outside even if they have access to a warm barn (Samson, 1996). Samson (1996) also reported "Trembling is a

behaviour that resembles shivering. It is often noticed in birds suffering from stress, such as, when confined or transported. Thus it is a manifestation of anxiety and should not automatically be interpreted as indication of hypothermia". As ostriches lack a preen gland and thus may have poor waterproofing of the feather cover, then this may lead to a major disruption of the insulative properties of the plumage during wetting. This is known to increase heat loss markedly and cause profound hypothermia especially in conjunction with air movement, in other birds (Mitchell et al., 1997).

In hot climates ostriches lose heat opening their wings and fluffing up their feathers to expose bare skin on their thorax and upper legs to enhance convective and radiative losses (Samson, 1996; Skadhauge and Dawson, 1999). Piloerection is employed to increase insulation against heat gain (Calder and King, 1974). They have no sweat glands (Samson, 1996). An increase in insulative thickness of 7cm has been measured in adult ostriches during heat stress (Calder and King, 1974). Infrared thermography indicates that the ostrich employs the beak, neck, lower leg, feet and toes to specifically regulate heat exchange (Phillips and Sanborn, 1994). The most obvious response to heat exposure is panting and gular flutter which increase respiratory evaporative water loss and therefore heat loss (Calder and King, 1974). Osmoregulation and thermoregulation are closely linked and the ostrich is well adapted in the co-ordination of these, sometimes, conflicting demands (Skadhauge, 1981; Skadhauge et al., 1996). Potent water reabsorption in the intestinal tract and kidney conserves water, which may be used in evaporative cooling. The emphasis on water conservation in the ostrich is hard to reconcile with the observation that the naked neck epidermis of the ostrich has poor "waterproofing" and does not constitute an effective barrier to water loss (Menon et al., 1996). In fact, ostriches lack a preen gland and so do not have the ability to oil their feathers to provide a waterproof plumage (SCECPAFP, 2003).

It was argued that in birds relying on Cutaneous Water Loss (CWL) for thermoregulation the presence of such a barrier would compromise heat loss, however, the ostrich has such effective Respiratory Evaporation Water loss by panting (REWL) that CWL may not be important during moderate heat stress. Indeed in a fully hydrated, adult ostrich at environmental temperatures up to 35C all significant evaporation is respiratory and REWL represents 98% of total evaporative heat losses (TEWL) (Calder and King 1974). In severe heat stress, particularly if air temperature exceeds body temperature (Ta > 40C), CWL may become more important but a 100 kg ostrich is capable of evaporating (TEWL) 11.0g of water per minute under these conditions, which is 100% of the heat dissipation and will adequately regulate deep body temperature (Calder and King 1974; Whittow 1976; Skadhauge 1981). So effective are the thermoregulatory mechanisms in the ostrich that "true hyperthermia", where body temperature is regulated 2-4C above the normal value, is rarely seen in these birds (Calder and King, 1974).

In many birds the thermal polypnea (panting) during heat stress may lead to excessive pulmonary ventilation and acid-base disturbances, specifically hypocapnic alkalosis due to loss of carbon dioxide (Phillips et al. 1985). Even in severe heat stress there is minimal alteration in arterial pCO_2 in the ostrich indicating that most of the ventilation is acting in thermoregulation and little is passing over the gas exchange surfaces of the lung (Phillips et al., 1985).

This may also lead to small reductions in oxygenation. Ostriches thus rely upon active heat dissipation during thermal stress rather than heat storage, which is employed by many other animals for purposes of water conservation (Calder and King, 1974). The option selected in the evolution of the ostrich is to employ this water to lose the heat and to maintain a very stable deep body temperature. In the above conditions, and if heat stress persisted over many hours, then addition of the basal water loss and the demands imposed by thermoregulation indicate that the bird would require 4-5 litres of water per day.

In an animal relying heavily upon evaporative cooling, the ambient humidity is an important factor as the efficiency of evaporation depends upon the gradient of water vapour density between the evaporating surface (e.g. the respiratory tract) and the air (Mitchell and Kettlewell 1998). Rises of humidity may impair evaporative heat loss; therefore artificial environments should be ventilated with a view to removing heat as well as water vapour. When considering the thermal environment of ostriches in commercial production, particularly during transportation, then ventilation rates have to be calculated upon a sound scientific basis (McKeegan and Deeming, 1997).

A starting point may be knowledge the standard or basal and total metabolic rates (SMR, BMR or TMR) of the birds from which the mass air flows required to dissipate the heat load may be calculated. Estimates of SMR in ostriches are often based upon empirical relationships between body mass and heat production or oxygen consumption (Calder and King 1974) yielding values such as 114W for a 100 kg bird (Whittow 1976). Other studies (Withers 1983) using measurements of oxygen consumption suggest that the BMR of a 100 kg ostrich is best described by:

ml oxygen per hour = 389 $kg.^{0.73}$

The TMR in active fed birds may be at least 2-3 times the basal value as suggested by McKeegan and Deeming (1997). This is confirmed by calculation of the BMR of a 88.5 kg ostrich from the equation of Withers (1983), which gives a value of 57W and comparison with measures of field metabolic rate (FMR) in birds of this size, made by Williams et al., (1993), who reported a energy metabolism of 18040 kJ per day which equates to 209W (3.7 fold basal).

Ventilation rates can therefore be calculated from

Flow rate (m^3 s^{-1}) = total heat loss from animals (kJs^{-1}) / dT x c_p where

dT = the acceptable temperature rise (C)

c_p = the specific heat capacity of air (kJ kgC^{-1}), assuming a density of air of 1.183 kg m^{-3}.

Thus, for 100kg captive ostriches with a metabolic heat production of 160W, airflow of 0.134m^3 would be required for a 1.0 C acceptable rise in air temperature. Such information is extremely important in the development of controlled artificial environments for ostrich transportation, in order to match conditions to the bird's biological requirements and to minimise stress and improve welfare.

The fan ventilation rate calculated as described above would maintain the internal environment within prescribed limits. If a maximum lift of 5C was designated for a single deck carrying 50 ostriches on than an absolute minimum ventilation rate of 1.34m^3s^{-1} would be required. For the operational flexibility required in the range of climatic conditions encountered in commercial practice fans with a capacity of 4-5 m^3s^{-1} are required to be installed.

The control of temperature and ventilation is particularly important in case of chick transport, since they need to be kept at 35C for the first week of life, which temperature could be reduced by 3C in each following three weeks, thereafter chicks becoming increasingly resistant to climatic changes (Hallam, 1992).

9.5. Feeding and watering

The ostrich is unusual in that it is a monogastric herbivore or "hind gut fermenter", at least in the adult (Dean et al., 1994; Skadhauge et al., 1996). Some young birds may be supplementing their vegetable diet with insect protein (Milton and Dean, 1993). They need to consume stones and they are well known for their ability to swallow unusual objects (Deeming and Dick, 1995; Deeming and Bubier, 1999). As consequences of environmental changes, stressed ostriches tend to pick up and eat a variety of harmful materials (Foggin, 1992). This may result in proventricular impaction (Wotton and Hewitt, 1999).

Healthy ostriches drink relatively large amounts of water (up to 80 litres/day – Paleari et al., 1995). They have a scooping action when drinking, therefore water containers should have a surface area at least of 12 square inches (Wotton and Hewitt, 1999). During periods of water deprivation their kidney can conserve water by producing an extremely concentrated urine excreting urates (Levy et al., 1996). Therefore, an indicator of inadequate hydration is the appearance of white, thick, concentrated urine, a change in appearance that takes place within two days of water withdrawal (Levy et al., 1996). However, it must be taken in account that laying hens, which are not dehydrated, can show a similar discolouration (Levy et al., 1996).

Wotton and Hewitt (1999) reported different management options for food and water withdrawal before transport, but all of them are taken from the practice or existing guidelines (Harris, 1996; DBV-SPCA, 1996; MAFF, 1998).

They can be summarised as following:

- complete food and water withdrawal but journey duration less than six hours;

- for birds over 18 months – four hour food withdrawal but the journey not longer than 12 hours (Harris, 1996);

- 12 hour food withdrawal before transport (used in the practice in South Africa);

- if the journey longer than 12 hours, light feeding the birds before departure and provision of water every 4.5 hours. However, ostriches seem to be reluctant to drink or eat during long journeys. According to Wotton and Hewitt, (1999), this might not represent a major concern because of the ostrich adaptation to desert environment makes them better able to face periods of water and food withdrawal. Notwithstanding their capability to stand long water withdrawal periods, by concentrating their urine, it is not known if this condition represents a psycho-physiological sufferance for the birds.

Lairage

There is a lack of scientific information on the effect of driving on transport stress, as well as of resting periods or lairage before slaughtering.

According to Veronesi et al., (2000) a 24-hour lairage after transport, with only water provided, is beneficial to the ostriches to restore their muscle glycogen reserves and eliminate the lactic acid accumulated along the journey. If this resting period is not allowed before slaughtering, it could to excessive increases of pH meat with deterioration of carcase quality.

Information on the slaughtering and nutritional value of the ostrich meat are reported in Paleari et al., (1995), on post-mortem pH decline in different muscles in Sales and Mellett (1996). In particular, the mean ultimate pH values seemed to greatly vary between different types of muscles, which factor was determinant for the rate and the extent of post-mortem pH decline (Sales and Mellett, 1996). pH values were within the normal range for poultry leg muscles, but since ostrich meat is darker in colour than beef, comparison to red meat was considered more appropriated. On this basis, ostrich meat may be classified as an intermediate type between normal (pH < 5.8) and extreme DFD (pH > 6.2) (Sales and Mellett, 1996). In ostrich this condition seems to be due to the high proportion of muscle fibres adapted for glycogenolytic metabolism (Ashmore, 1974, cited in Sales and Mellett, 1996).

9.6. Diseases

Several pathological conditions would lead to particularly poor welfare during transport. Lower limb deformities, chiefly tibiotarsal rotation, are the most common causes of death in ostriches, followed by OFCS and salmonellosis (More, 1996; Ashash et al., 1996). Tibiotarsal rotation affects significant numbers of ostrich chicks (>5%) and rolled toes and phalangeal deformities can be observed in up to 25% of some batches of chicks (Dick and Deeming, 1996), and have been reported elsewhere for “twisted leg” and “slipped tendon” (Allwright, 1995). The incidence of orthopaedic diseases in ostriches may constitute a major problem in commercial ratite production and transport (Gnad et al., 1996) and as such may develop into a major welfare issue much as it has in commercial poultry production. Paresis is a relatively common problem in captive young ostriches (Weisman et al., 1993). Viral diseases of avian in general affect ostriches also – e.g. avian influenza. This aspect is of major importance when considering possible disease transmission related to animal transport.

Other nutritional problems resulting in pathology and poor welfare during transport include vitamin E-selenium deficiency (Van Heerden et al., 1983) which may result in myopathy or nutritional muscular dystrophy (Vorster, 1984). Stress induced myopathy responding to vitamin E treatment has been reported in other ratites (Patak and Baldwin, 1996). Incidents of nutritional myopathy in commercially reared ostriches have occurred, presenting paresis accompanied by greatly elevated CK activity and striping of skeletal muscle (Dick and Deeming, 1996).

As with other species, a range of infectious diseases may be spread when ratites are transported. The birds themselves, people who travel with them, or faeces and other products may be the source of transmitted pathogens.

Mortality and carcase damage

These aspects have been well reviewed by Wotton and Hewitt (1999). Poor handling and transportation may result in trauma, which has been found to be the major cause of mortality in birds over three months (Wotton and Hewitt 1999). Fractures occasionally occur, primarily in the long bones of the legs and the wings (Foggin 1992), which often result from incorrect handling (Wotton and Hewitt 1999). Some ostrich farmers used to tape the wing to the side of the birds for preventing trauma, but this method may cause undue stress and affect bird ability to balance (Wotton and Hewitt, 1999). Neck and lower leg lacerations may be induced by restraint operations (Wotton and Hewitt 1999). Many of the pathologies or injuries affecting captive ostriches result in lethargy, weakness or fatigue, ataxia and impaired mobility and consequently the birds may exhibit recumbency. In the absence of overt trauma a diagnosis of proventricular impaction should be considered, particularly with signs of chronic inappetance, dehydration, weight loss and a failure to respond to laxatives (Shakespeare 1995; 1996; Deeming and Dick 1995; Putter 1996).

Capture myopathy, as a result of physical exertion, can occur if ostriches are driven too hard, or struggle excessively during capture, handling and transport operations (Wotton and Hewitt 1999). Affected animals are unable to stand or walk without difficulty, and death may occur within hours or weeks (Wotton and Hewitt 1999). The causes may be a lack of blood circulation during transport being the legs are kept too long folded underneath the body while sitting; In addition there may be an accumulation of muscle lactate (ostriches muscle are very rich of glycogen), leading to rhabdomyolysis, followed by gastric and intestinal failure, and general intoxication (Veronesi et al. 2000).

Carcase damage can be induced by insufficient space during transport, where the birds cannot sit down, a condition which enhances the risk for them to be trampled, with occurrence of traumas (Wotton and Hewitt, 1999). Since any damage, such as kick mark scars, bruising or fresh wounds, downgrades ostrich tannery, the safeguarding of the welfare during handling, transport and slaughter is usually of prime economical importance for the operators (Wotton and Sparrey 2002). In the EU, the skin value is about 50% of the carcase value and ostriches bruise easily, therefore the use of sticks is discouraged, (Hallam 1992).

During transport, ostriches seem to be more severely affected by hot weather compared with low temperatures, particularly if water is not available (Wotton and Hewitt 1999). High temperatures combined with inadequate ventilation can greatly increase mortality rate (Wotton and Hewitt 1999).

10. TRANSPORT OF DEER

10.1. Introduction

There are a number of detailed reviews on various aspects of the welfare of farmed deer (Goddard and Matthews 1994; Goddard 1998; Pollard and Wilson 2002; Wilson and Stafford 2002) and specifically on handling and transportation (Matthews 2000; Weeks 2000). MAFF Codes of Recommendations and Minimum standards for deer handling, transport and slaughter have been established for safeguarding deer welfare during these crucial phases (MAFF 1989b). In New Zealand, (New Zealand Animal Welfare Advisory Committee, 1994; 1996) these have been implemented by the deer industry, which has developed a specific on-farm Quality Assurance (QA) system that defines good management practices and minimum standards in materials and construction. This has a substantial animal welfare component, covering all phases of deer production, and must be followed by all accredited deer farms (Pollard et al. 2002). Deer are recently domesticated animals, and farming practices used for traditional farm animals may have potential detrimental effects on their welfare (Goddard and Matthews, 1994). A thorough knowledge of the ethology and biology of the deer is therefore essential not only for safeguarding their welfare but also for optimising production systems (Goddard and Matthews 1994).

10.2. Deer farming

Deer have been kept in game parks for many years, and for many centuries there has been a practice of population management to limit their numbers. In recent times different deer farming practices have been used in several European countries, ranging from very extensively farmed systems in areas of marginal agricultural land, to intensive units in more fertile high quality lands. Trophy hunting is also carried out, as well as placing deer in nature reserves for the purposes of tourism. In particular, in Europe, there is a large variation in management technologies and personal "know how" for deer farming. Deer farms can be classified according to grazing density as extensive (1 head/ha), semi-extensive (from 1 to 3 head/ha, food integrations in winter and summer) or intensive (> 3 head/ha and regular feed supply) (Diverio et al., 1997). Another determinant factor to differentiate deer farming is management, which varies from a very high level (1st Category Deer Farms, provided with adequate fencing, paddocks and raceways connected to proper deer handling crushes where deer are routinely handled and can be individually captured, disease and reproduction control, etc.) to very low standards (3rd Category Deer Farms, lacking of any form of deer handling facilities, and where animals are collected in different ways, i.e. by nets or chasing to corrals, only at slaughtering time (Diverio et al. 1997).

Deer belong to the family Cervidae and the most common farmed species in Europe are red deer (*Cervus elaphus*), fallow deer (*Dama dama*) and reindeer (*Rangifer tarandus tarandus*) which are considered separately as they have been farmed for very much longer than the other species. In the initial systems of deer farming, shooting the deer in the field was the most common method of culling, and the majority of animals were butchered locally as venison obtained by hunting (Weeks 2000). When an individual was shot the rest of the herd stopped feeding, trotted for a short distance and then stopped, starting to graze again (Smith and Dobson 1990). Red deer shot in the field showed low average plasma cortisol concentrations and muscle pH compared with deer herded on the farm or transported to the abattoir (Smith and Dobson, 1990). Results of a study comparing three different pre-slaughter management systems in fallow deer (transport and lairage in small groups within wooden boxes, transport and lairage in a pen or shot on pasture) confirmed that field slaughter was the least stressful method (Diverio et al. 1998b).

However, since the recent expansion of deer farming, for economical and meat hygiene reasons, most farmed deer are nowadays transported to specific abattoirs for slaughtering (Weeks 2000). Deer have been successfully transported by air, sea, and land, travelling by a variety of systems, providing appropriate handling methods (Haigh and Hutson 1993). Appropriate methods of handling and transport had to be developed, taking in to account the reactive and social nature of these recently farmed species and their sensory capabilities.

10.3. Deer senses and physical abilities

The principal aspects of deer senses and physical abilities have been reviewed by Matthews (2000), who reported that: "Deer are considered to have a similar wide visual field to the other farm ruminants (about 300° with a blind spot to the rear and at ground level to the front of the animal when the head is raised) and good depth perception in the small area of binocular vision". Deer detect moving objects readily but do not respond well to static objects (Cadman, 1966; McNally, 1977)". That is why 'foreign objects' left lying around may upset the deer, and it is advisable to check for such objects along passages before moving the animals (Yerex and Spiers 1987).

Matthews (2000) also highlighted that "Since deer are active at night they must have excellent vision under low light conditions. Deer have also an acute sense of smell and hearing and, compared with other farm animals, they are very agile. Most species are able to clear barriers of 2-2.5 m in height from a standing position or to accelerate almost instantaneously from 0 to 50 km h^{-1} (Drew and Kelly 1975). In their environment they tend to move along well-defined trails (Cadman 1966) and if facing an obstacle, they seem to prefer to go under or push through it rather than go over it (Clift et al. 1985).

10.4. Measurements of stress in deer

Physiological and behavioural indicators of stress commonly used in other farmed species have been suitable also for assessing stress in deer (Brelurut, 1991, Goddard and Matthews, 1994; Goddard and Grigor, 1997; Goddard, 1998). ACTH stimulation tests (Bubenik and Bartos, 1993; Goddard et al., 1994) have been exploited as measurements of chronic stress, also by pretreatment with dexametasone to suppress the animal's endogenous ACTH output (Smith and Bubenik, 1990; Zomborszky et al., 1993). Responses to exogenous ACTH have been suggested as a tool for selecting the most suitable individuals for domestication (Seal et al., 1983; Goddard and Matthews, 1994). It is important to underline that, in deer, the adrenal gland has been also recognised as an important source of progesterone in response to stress, or following ACTH stimulation (Jopson et al., 1990). Plasma progesterone levels increased in restrained/handled deer (Jopson et al., 1990; Matthews et al., 1990; Matthews and Cook, 1991; Ferre et al., 1998).

Quantification of lactate dehydrogenase (LDH) and its isoenzyme distribution, as markers of muscle damage as part of the physiological response to stress in deer, have been studied by Goddard and Grigor (1997). They have found that LDH-5 was the component most associated with skeletal muscle. There was a good correlation between CK and LDH5, but not with cortisol levels, probably because both CK and LDH were indices of physical stress while changes in cortisol concentrations were caused by psychological factors (Goddard and Grigor, 1997).

Sampling methods for measuring physiological changes may act as confounding factors since they require restraint and handling of each individual, which have been already proved to be stressful for deer (Goddard, 1998; Matthews, 2000). In order to avoid this considerable sampling artefact, some remote blood sampling devices have been developed and successfully used in deer (Goddard et al., 1993; Bubenik, 1982; Diverio et al., 1993; Ingram et al., 1994; 1997; Waas et al., 1999). Remote heart rate monitoring has been also widely utilised (Diverio et al., 1993; Pollard et al., 1993; Carragher et al., 1997). It is important to note that heart rate is also influenced by season, age, fitness, type of activity, physiological state and psychological stress (Jacobsen, 1979; Price et al., 1993; Weeks, 2000), thus, these variables have to be considered when measuring the sympathetic response to physical stressors.

Goddard (1998) suggested motivation studies as alternative methods of assessing stress in deer. These behavioural measurements are focused on an animal-centred perspective, attempting to evaluate the strength of desire for a resource. In addition, preference/aversion studies restricted to comparing pairs of situations have been also suggested as measurements of the degree of pleasure or aversiveness to specific procedures (Goddard, 1998). The relative aversiveness to farmed deer of transport, physical restraint, human proximity and social isolation have been measured by using latency to enter and time to move down a raceway (Grigor et al., 1998b). Restraint and transport were found to be the most aversive treatments (Grigor et al., 1998b).

Stereotypes such as fence pacing should also be considered as sign of environmental or management stress (Hediger, 1964; Diverio et al, 1993; Pollard et al., 1993), as well as any disruption of behavioural activity pattern or increase in aggressive interactions or abnormal behaviours (Pollard and Wilson, 2002).

10.5. Handling facilities

Farmed deer maintain their wild anti-predator strategy, characterised by alertness and flight (including jumping), fight (bites and kicks), gathering together when threatened (Weeks, 2000). Several studies on deer handling have proved that interaction with humans can be stressful to deer (Pollard et al, 1994; Pollard and Littlejhon, 1994; Grigor et al., 1998b; Pollard et al., 2002). Price et al., (1993) recorded an increase of heart rate when the deer were merely approached by handlers. If they have the choice, deer tend to avoid human presence (Pollard and Littlejhon, 1994) and the strong aversion of deer to human proximity partially explained their reluctance to enter a raceway or to be restrained (Grigor et al., 1998b).

Specific handling facilities and management procedures are required for deer transport and management. Principles of deer handling have been described by several authors (Yerex and Spiers, 1987; Haigh and Hudson, 1993; Diverio et al., 1997; Matthews, 2000). According to them, deer are best handled by a minimum number of people. Unusual noises are disturbing to deer and individuals readily break off from a group (Yerex and Spiers, 1987). Deer should be driven from the pens or into raceways as a group, moving them steadily, without sudden movements, talking to them in a low voice, calming nervous animals to avoid agitation spreading to the others (Yerex and Spiers, 1987). During the rut, stags should be handled as seldom as possible, since they are naturally aggressive (Yerex and Spiers, 1987), particularly if they have been hand-reared (Asher personal communication).

Layout can facilitate moving deer from paddocks into a race, for example cutting corners off with a fence, or locating shelter trees to create a funnel effect at the entrance of the gate (Yerex and Spiers, 1987). This has to be wide enough to be clearly visible to the deer (at least 3.5m wide) (Yerex and Spiers, 1987; Weeks, 2000), preferably located near the corners on flat areas or otherwise at the top of the rises since deer prefer to move up hill rather than down (Matthews, 2000). Due to their natural tendency to bunch together, a raceway at least 5m wide for red deer (Matthews, 2000), 3-4m for fallow deer (Yerex and Spiers, 1987), is needed for initial movement and then about 1.5m wide in the handling facilities (Weeks, 2000). Grigor et al., (1998c) found that deer moved less readily in a 4m wide loading race, where they were able to turn around and run past the handlers, compared with a 1.5m wide one. Deer became quickly accustomed to move through such a raceway, and moved faster than in a 0.5 m wide, single-file race (Grigor et al., 1997c). A raceway needs to be constructed with smooth corners since deer tend 'to cut' them, which may lead to injuries (Matthews, 2000). It's commonly recognised that deer move more readily in winding raceways compared with straight ones (Haigh and Hutson, 1993) and flow best into yards if they are turned through a curve on the final approach (Matthews, 2000). However, Grigor et al., (1998c) found that the shape of the loading race (straight or curved) did not influence the time taken by red deer to enter the trailer. This is in agreement with their previous findings (Grigor et al., 1997c) and with Matthews (2000), who suggested that as long as the animals are kept moving, straight or curved races are equally effective. To reduce the risk of collision with fences, on the raceways approaching the yard, an increasing number of vertical wooden battens becoming solid boarding at the end has been found to work well (Haigh and Hudson, 1993; Matthews, 2000). New Zealand intensive deer farms are usually equipped with purpose-built yards with solid wooden walls, about 3 m high, sometimes covered with a roof, (Pollard at al., 2002). The handling areas may contain a number of pens, an enclosed individual weighing area and a wooden crush or handling cradle, to capture the animal by either dropping the floor or by holding the animal between the two sides by using a hydraulic mechanism (Pollard at al., 2002). Farmed fallow deer restrained by straps in a box had high cortisol, LDH, CK and NEFA blood concentrations but these concentrations were lower in deer held in a crush (Diverio et al., 1998c).

Herding and handling red deer has also been shown to increase heart rate, physiological indicators of stress and muscle damage, as well as ambulation once they are released back to pasture (Diverio et al., 1993; 1996a; Carragher et al., 1997). Increases of plasma enzyme activities in response to capture and handling stress were influenced by herding time (Ranucci et al., 1996). Physical restraint in a deer crush and transport were found to be more aversive compared with human presence or visual isolation (Grigor et al., 1998b). Carragher et al., (1997) carried out a comparative study on the effects on red deer stags of three different management treatments: a) Pen: confinement in a pen for 12 min; b) Draft: as for the Pen, but a handler entered the pen twice and simulated drafting; c) Crush: as for the Draft, but each deer was drafted (isolated) from the group, moved down to a raceway and restrained for two min into a drop-floor pneumatic restraint device. Draft and Crush treatments were shown to be slightly more stressful than pen confinement (Carragher et al., 1997). However, the behaviour and physiological changes remotely collected (blood pressure and heart rate) rapidly decreased once the deer were released from the yard, (Carragher et al., 1997). Similar results were previously reported by Price et al., (1993) who found restraint in a deer crush was the most stressful procedure. Also the paddock environment with handling facilities has been shown to be a source of stress for deer (Diverio et al., 1993). However, behavioural and physiological changes induced by handling stress are usually short-lived, and deer can become accustomed to humans and routine handling (Haigh and Hudson, 1993; Goddard, 1998; Weeks, 2000). Pollard at al., (2002) suggested that "Handling stress can be reduced by taming, habituation, selection for temperament, training handlers or improving handling environments". In Europe at present, most farmed deer are not habituated to humans but are fearful of them so their welfare during handling and transport is generally poor. Long-acting neuroleptics have been successfully used to reduce the stress response to management practices in red deer (Diverio et al., 1996a).

10.6. Influence of light conditions

In deer farming, it is a common practice, particularly with flighty species such as fallow deer, to reduce the level of illumination when handling the animals, as darkness is believed to quieten the animals (Kay et al., 1981; Yerex and Spiers, 1987; Pingard and Brelurut, 1998; Matthews, 2000; Weeks, 2000). Obscuring the eyes with a cloth when animals are restrained is also used (Matthews, 2000). Fallow deer, kept in the dark in holding pens will move towards the lit entrance of the handling race or crush (Langridge, 1992; Diverio et al., 1997; Matthews, 2000). According to Asher (Asher, G.W., personal communication) there are radically different behaviour patterns between red and fallow deer: red deer move from the light into the dark, whereas, fallow deer move from the dark into the light. However, the effect of light on deer behaviour has been investigated by few scientific studies.

Pollard and Littlejohn, (1994) tested two levels of illumination – bright (200 lux) – and dark – (0-1 lux) on penned yearling hinds. Deer confined in darkened pens showed a reduced behavioural reaction to human presence compared with those located in brightly lit pens (Pollard and Littlejohn, 1994). In the dark they were more dispersed, showed less locomotory and more nosing activity, supporting the possibility that fear was reduced and that the welfare of deer might be improved by darkening holding areas (Pollard and Littlejohn, 1994).

In subsequent experiments, Pollard and Littlejohn (1995) found that lighting conditions during handling had an effect on heart rate and behaviour of castrated red deer. In an unfamiliar pen, deer did not confine themselves in the darkest areas, but they seem to prefer the dimly lit areas, regardless of the presence of humans. Heart rate was measured when deer were restrained in a mechanical deer crush for two minutes, under either dark (0lux) or light (1,500lux) conditions. Heart rate was significantly lower in the dark compared with the light at the start of the observation period. Heart rate then decreased overall, reaching similar values in the two treatments. These results, since elevated heart rates have been associated with stress in deer (Pollard et al., 1993; Price et al., 1993) seemed to suggest that dark treatment reduced the stress response to restraining. However, since lowered heart rates have also been associated with difficult situations and increased attention to environmental stimuli (Fraser and Broom, 1990), these results might not provide conclusive evidence that stress was reduced (Pollard and Littlejohn, 1995).

The effects of illumination inside the vehicle were also examined (Grigor et al., 1998c), as a strategy to facilitate loading operations. However, the presence of a light, angled instead of shining into the eyes of the oncoming deer as recommended by Grandin (1990), had no effect on the time taken to move through the loading raceway and enter the trailer (Grigor et al., 1998c).

10.7. Isolation and mixing

Both isolation and mixing with unfamiliar conspecifics may be potential sources of stress for deer. Wild deer are social animals, whose herd structure varies widely according to sex, age, season and environmental conditions (Pollard at al., 2002). During most of the year, adult stags and hinds are sexually segregated, with hinds normally associated within matrilineal groups. Juveniles stay with their mothers for 2-3 years, while stags form loose associations within them (Clutton-Brock et al., 1982; Chapman, 1993). As the time of antler cleaning approaches, stags tend to isolate and disperse from their social group (Bartos, 1985), whereas during the rut, they establish and defend their own harem (Clutton-Brock et al., 1982; Chapman and Chapman, 1975). A 'lekking' strategy, whereby a number of bucks hold a small territory, in very close proximity to each other, can also be adopted by fallow deer stags (Chapman, 1993; Pollard et al., 2002).

Mixing of social groups is believed to contribute to pre-slaughter handling stress in farmed deer (MacDougall et al., 1979; Kay et al., 1981; Alexander, 1988; Selwyn and Hathaway, 1990). Pollard et al., (1993) found that in yearling stags, visual and spatial isolation from familiar stags induced increased heart rate, and an increased frequency of ambulation and activities directed to the perimeters of the enclosures, in particular of nosing behaviour, suggesting attempts to escape. Mixing and confinement in a pen with other unfamiliar stags also induced similar changes (smaller increase of heart rate, ambulation and head movements toward the perimeter of the pen), associated with an increase of aggressive interactions and a decrease in grooming behaviour (Pollard et al., 1993). Confinement in isolation or with unfamiliar deer represented potential aversive social stimuli for red deer stags, therefore they have to be considered as factors contributing to handling and transport stress. The aversiveness to social isolation as been also measured by placing individual yearling hinds in an empty pen (3m x 3m) adjacent to a raceway for five minutes (Grigor et a., 1998b). The latency to enter the raceway in such deer did not differ significantly from control deer, probably because deer gained some experience during the pre-experimental period. In fact, in a Y-maze test, deer showed that they could learn rapidly (after one exposure to each treatment) the difference between the treatments applied in the two arms of the maze (Pollard et al, 1994b).

Repeated mixing of groups of red deer yearlings was found also to affect immunological responses (Hanlon et al., 1995). Grouping similar-sized individuals together is recognised as good management practice (Matthews 2000). Since social mixing of housed deer can induce increased aggression and physiological indicators of stress (Hanlon et al., 1995), once groups are established, it is advisable to leave them intact (Pearse and Fennessy, 1989; Pollard et al., 2002).

10.8. Animal preparation (loading and unloading)

Fletcher (1988) stated that "The factors most likely to cause problems (in transportation) are, in order of priority: overcrowding, mixing of different sizes and categories of deer; unsuitable bedding; overexcitement during loading; high speed cornering and braking; dehydration; unsuitable vehicles and excessive length of journey." Subsequently, several studies have considered aspects of transport on deer, demonstrating that this was both physically and psychologically stressful for them (Goddard, 1998). Loading and unloading procedures are a stressful component of transport. Heart rate significantly increased during loading and unloading before and after transportation in farmed red deer (Horalek and Jones, 1993; Grigor et al., 1998d). The New Zealand Animal Welfare Advisory Committee Codes (1994; 1996) recommended a standard slope of 20C for loading ramps for deer. Their walls need to be high enough to prevent the deer from attempting to jump out (Haigh and Hudson, 1993). Deer need time to move quietly along unloading ramps and races.

Pre-transport conditions may influence the reaction of livestock to be loaded (Grigor et al., 1998c). According to Fletcher (1988) it would be beneficial to gather the deer into pens on the day before transport. However, many studies show that overnight or longer lairage before slaughtering the deer, although it allowed some biological recovery, represented a further cause of stress (Grigor et al., 1997b; 1998a; Diverio et al., 1996b; 1998b). In a study of pre-transport conditions, previous overnight housing did not influence loading operations (Grigor et al., 1998c). Over the two experiments, contrasting results were obtained regarding the numbers of attempts required to load the deer during following trials. The results of the first experiments suggested that deer learnt that loading represented an aversive experience, rather than becoming accustomed to such a procedure (Grigor et al., 1998c). On the other hand, in the second experiment the deer tended to take progressively less time to enter the raceway and the trailer. These contrasting effects were attributed to the different widths of the races used (4m vs 1.5m; see discussion in handling facilities) (Grigor et al., 1998c).

10.9. Journey management

10.9.1. Vehicle design

Pollard et al. (2002) stated that: "All accredited deer transporters need to use purpose-built deer crates, which are specifically designed to allow for freedom of movement, unimpeded flow of ventilation, ease of handling, security and safety for both the animals and their handlers (drivers)". Ceilings are usually 1.8 - 2m high but in many trucks this height can be varied according to the class of stock . Normal flooring is of 19mm^2 woven mesh and allows for safe and secure footing and the drainage of effluent. Maximum pen sizes have been established for the carriage of all deer on a loading density criterion based on deer being a live weight of 100kg. The maximum number of deer per pen under these criteria is 8 (100kg deer). However pens are normally designed for and used to carry 6 (100kg) deer. Many new deer crates commissioned recently have water sprinkler systems for use when deer become unsettled, which is normally attributed to overheating".

Adequate ventilation is of major importance in deer transport for example a continuous opening of not less than 100mm in width on the external walls or along the roof of each pen, or an equal area of ventilation. Cases of corneal opacity have been observed after long journeys in deer, and these have been suspected to be caused by too much exposure of the face to the wind or the use of straw as bedding (Tedford, 1997). Light near the top of the trailer may lead to jumping. Practical experience suggested that a 2-inch gap at the base of the floor for fallow deer to look out would calm them and avoid jumping (Tedford, 1997).

10.9.2. Animal preparation (in handling)

10.9.3. Travel times (road type)

Goddard, (1998) stated that: "Transport on winding roads was more physically demanding, with a greater risk of injury. However, most changes were short-lived and reversible,"

The effects of a range of transport distances (80, 230 and 400km) on red deer hinds were studied (Jago et al., 1997; Jago and Matthews, 1998). The greatest losses of balance, number of impacts, movements and rapid foot adjustments were concentrated at the start of the journey, and when travelling on a hill or on winding roads (Jago et al., 1997). Lying down was not recorded during the first 60 minutes journey, but increased afterwards. Pre-slaughter handling (including transport) resulted in an increase of plasma enzyme activities (CK, AST, LDH, LDH3, LDH4 and LDH5), which was proportionate to journey length. Overall carcass bruising levels were low, but they increased progressively with travel times (from a mean of 5.2 to 10.7 hrs) (Jago et al., 1997; Jago and Matthews, 1998). Bruising was negatively correlated with fatness, as already observed in a previous survey on deer commercial slaughterhouses (Jago et al, 1993), confirming that leaner animals are the most at risk of bruising. In farmed fallow deer, notwithstanding 36 hours of lairage, at slaughter, a greater physiological response to stress (cortisol, glucose, fat metabolites and muscle enzyme activities) was found in animals transported for 4 hours compared with those transported for 2 hours (Diverio et al., 1998a).

Effects of road type and journey time were also studied (Grigor et al., 1998d). Signs of greater physical and psychological stress were observed during transportation up to 6 hours, when travelling on winding roads. More losses of balance and a greater increase in plasma CK activity occurred with winding roads compared to straight ones. Overall, during the initial stages of transport, deer showed live weight losses, increased standing, moving and alert behaviour, and increased heart rate. These parameters tended to decrease with time, suggesting a partial adaptation to transport as journeys progressed. However, following a 6 hour journey, deer spent more time eating, higher PCV and plasma CK activities were found, and there was a larger increase of plasma sodium concentrations during the recovery period, suggesting that the longer journey was more physical demanding for them (Grigor et al., 1998d). Similarly, Waas et al., (1999) found a linear increase of cortisol in relation to transport time, confirming that deer became progressively more stressed during 2 hour journeys. In a survey on commercial abattoirs, significant increases in levels of bruising and consequent downgrading (varying from 3.8% to 14.2%) were associated with increased journey length (Jago et al., 1996).

In conclusion, overall studies seem to suggest that transport time need to be minimised as much as possible for farmed deer.

10.10. Space allowance

10.10.1. Transport by road (floor/space allowance; factors affecting the space needed: age, sex, group size, method of transport)

Overcrowding deer in the vehicle can lead to overheating, an increase of aggression and injuries (Haigh and Hudson, 1993). To avoid this, recommended minimum space allowances were provided by MAFF (1989b). MAFF (1989b) guidelines for road transport of farmed deer recommended the following minimum floor area allowances for deer:

adult stags 1m^2;

yearling stags and adult hinds 0.5-0.6m^2;

3-months old calves to yearling hinds 0.3-0.4m^2.

It was also recommended that deer should be segregated by age, sex, size and previous familiarisation, and they should be allowed sufficient space to lie down, get up and turn around. Not more than 10 yearling red deer or 20 fallow deer should be carried in one pen (MAFF, 1989b). The height of the vehicle should allow the animals to stand with ears erect (Haigh and Hudson, 1993).

Minimum recommended heights were:

1.53m for deer of 75-100kg;

1.22m for deer of 45-74kg;

1.00m for deer weighting less than 45kg.

The transport of stags, either in velvet or hard antlers, as well as during the rut, can cause problems (MAFF, 1989b). Weeks (2000) reported also the recommendations of the New Zealand Animal Welfare Advisory Committee Codes (1994; 1996): maximum eight deer are allowed in a pen, with minimum space allowance ranging from $0.22m^2$ per 40 kg fallow hind up to $0.96m^2$ per 200 kg red deer stags.

Adequate space allowance can be calculated according to body weight. An adult red stag weighs over 200 kg of live-weight, with top animals reaching up to 340 kg. An adult red hind averages 90 to 120 kg, with top animals reaching up to 140 kg. According to the following equation:

$$A = 0.021\ W^{0.67}$$

(where A is the area per animal in m^2 and W is weight of animal in kg), the following minimum space allowances are suggested:

$1.04^2 – 0.73^2$ for deer of 340-200kg;

$0.38^2 – 0.46^2$ for deer of 75-100kg;

$0.27^2 - 0.46^2$ for deer of 45-74 kg.

It can be noted that, whereas for lighter deer suggested space allowances are similar to those recommended by the New Zealand Animal Welfare Advisory Committee Codes (1994; 1996), as live weight increases, these are comparatively lower (i.e. 200kg: 0.73^2 compared with $0.96m^2$). It would seem that other factors other than weight have been considered by the New Zealand Animal Welfare Advisory Committee Codes (1994; 1996), may be the presence of the antlers or the need of greater social inter-individual distances.

Pollard and Wilson (2002) reported some special provisions for the transport of certain classes of deer (recently weaned calves, pregnant hinds, and hinds with calves at foot) in New Zealand. Calves transported after weaning should be immediately transferred from farm to farm, within a yarding and transport time not more than 6 hours.

Confinement

Short-term confinement in small pens, was shown to be aversive as the deer paced and made repetitive up-and-down head movements along the walls (Pollard and Littlejohn, 1996). The effect of movement to a novel environment (for 3-h and 6-h without food and water) and reduced space allowance (0.9 m^2/deer), as aspects associated to transportation, have been investigated (Grigor et al., 1997a). During treatment period, short-lived changes were observed such as loss of live weight, more time standing and moving and less lying and grooming, and a constant increase in the frequency of aggressive interactions (Grigor et al., 1997a). However, no significant changes in physiological measurements of dehydration (plasma sodium and osmolality) or indicators of stress (cortisol and NEFA) were observed (Grigor et al., 1997a). At slaughter, deer confined in a holding pen before stunning showed higher increases of plasma cortisol levels and lower liver glycogen concentrations than those which were stunned immediately (Grigor et al., 1999).

Grigor et al., (1995b; 1998a) studied the effects on behavioural and physiological reaction of a range of treatments (sex and group size, space allowance and vehicle motion). In particular, yearling red deer were Studied during transport at the lower end of the range of minimum recommended space allowances for each sex in the MAFF (1989b) compared with double this space . They were loaded for three hours in a livestock transporter, either moving or stationary. There were few differences between the various treatment combinations. Inside the transporter, regardless of different space allowances, only minor differences in mean temperatures were recorded, as well as very low ammonia concentrations (<5ml/m^3) (Grigor et al., 1998a). No differences in postures among treatments were recorded, but a general increase in standing and a decrease in lying were recorded during confinement or transport, particularly at the start of the journey (Grigor et al., 1998a; 1998d). These findings were attributed to reduced space allowance, since this has been already shown to affect deer behaviour when they are confined in a pen (Hanlon et al., 1994). These effects were greater in larger group size, suggesting a more pronounced behavioural disturbance when a greater number of animals were grouped together (Grigor et al., 1998a). However, with increasing transport time (up to 6 hours) time spent standing, moving and alert decreased (Grigor et al., 1998d). These findings are in agreement with other studies, which found that during confinement or transport the deer were mostly inactive, spending most of the time standing stationary (Jago et al., 1993; 1997).

Lower space allowance significantly influenced heart rate and plasma lactate concentrations, which were significantly higher (10-13% and 30-40% respectively) in deer transported at high density (0.38 m^2/84Kg animal) compared with those transported at medium

($0.62m^2$) or low ($0.85\ m^2$) densities, (Waas et al., 1999). Confinement on a transporter for 3 hours at different space allowances (males: $0.5m^2$ or $1\ m^2$/deer, females: $0.4\ m^2$ or $0.8\ m^2$/deer) had significant effects on most physiological indicators of stress measured (plasma cortisol, NEFA, CK, sodium, osmolality and heart rate). However, these changes were short-lived, returning to pre-treatment values shortly after unloading (Grigor et al., 1998a).

Confinement of red deer in a stationary trailer led to a reduction in heart rate after loading, but when the vehicle started to move the heart rate rose again, to fall rapidly again once the journey ended (Horalek and Jones, 1993). Elevated heart rates were then mainly associated with vehicle motion rather than noise or confinement (Horalek and Jones, 1993). Vehicular motion was shown to be more stressful than confinement alone, since deer loaded and confined in a stationary vehicle for three hours showed a lower increase in the plasma concentration of NEFA and cortisol compared with those transported for the same time (Grigor et al., 1998a).

As an effect of reduced space allowance, increased agonistic activities and pen-directed behaviour have been observed during stationary confinement (Grigor et al., 1998a), and after transport over increasing time of lairage (Grigor et al., 1997b). In another study, the lack of aggressive interaction between deer during transportation, was attributed to their continuous need to maintain the balance, as confirmed by the observation that more losses of balances were recorded for higher stocking densities (Grigor et al., 1998a). Jago et al., (1993) reported more impacts with pen walls or other deer during transport at high stocking densities ($0.49\ m^2$/deer) but fewer aggressive encounters. Red deer hinds transported over a range of distances (80, 230 and 400km) showed a large range of agonistic activity, 95% represented by bites, which were usually initiated by the heavier animals and directed at the lighter ones (Jago et al., 1997; Jago and Matthews, 1998). Within a group of deer confined in a pen, the lightest and smallest animals also tended to receive the most aggression (Pollard and Littlejohn, 1998).

10.10.2. Transport by air

Deer can also be transported by air and this can present special problems because of the lack of external ventilation (Haigh and Hudson, 1993). In order to avoid thermal stress and dehydration, an air conditioned environment and extra water (10 litres per head for red deer, Fletcher, 1988) should be provided, also when the plane is stationary at an airfield (Haigh and Hudson, 1993). Due to their moisture, root vegetables can represent an optimum supplementary food for deer during the flight (Haigh and Hudson, 1993). Crates built so that the excreta could be collected during the flight, horse trailers or even large stock liners can be used if basic rules are obeyed (Haigh and Hudson, 1993). The following red deer optimal densities for air travel are reported:

Table 10.10.2.1.: Minimum floor space allowance for red deer

Type/Class	Floor space (m^2)
Calves (3 month yearling hinds)	0.3-0.5
Adult female	0.4-0.6
Adult male (no antlers)	0.7-0.8
Adult male (in velvet)	3.3

(from Haigh and Hudson, 1993).

10.11. Bedding

Different types of bedding can be used in order to prevent slipping, to adsorb urine and faeces and to encourage deer to lie down (Haigh and Hudson, 1993). Non-slip rubber mats, hay or straw (which have the advantage that can be eaten) and sawdust (which should not lead to dusty conditions, leading to respiratory difficulty) have all been commonly used (Haigh and Hudson, 1993). Concrete or wire mesh gratings are mostly utilised in lairage pens (Pollard et al., 2002).

10.12. Thermal conditions

There is a lack of scientific information regarding thermal requirements during the transport of deer. According to Weeks (2000) they are more likely, as other ruminants, to suffer more heat than cold stress. However, deer are very poorly insulated and they suffer if exposed to cold and windy environments (Chapman and Chapman, 1975). If the deer are closely confined, high temperatures, particularly if associated with high humidity, can lead to heat stress since the only way they can dissipate heat is by panting (Harcourt, 1995). According to MAFF guidelines (1989b) “If animals are suffering by heat stress they may benefit from spraying with water. Heated animals should be given time to cool before to be released” (Provisions of the New Zealand Animal Welfare Advisory Committee Codes (1994; 1996).

Harcourt (1995) found that during transport the temperature inside the crate could rise up to 10C higher than outside temperature. Most risk from heat build-up occurs when the truck is stopped for any length of time, with body temperatures continuing to rise for up to 30 minutes after the truck continued its journey. In summer time, single crates were hotter than the lower deck of a double-decked vehicle (Harcourt, 1995).

In a study on confined deer, deprived of food and water, different ambient temperatures (9C, 13C and 20C) had no significant effect on behavioural and physiological responses (Grigor et al., 1997a).

Thermoregulation in red deer during transport has been investigated by measuring ambient temperature (T_a) either when deer were in the paddock or on the truck, and internal body temperature (T_b) by using an Intravaginal Temperature Logger (Matthews et al., 2000). Ambient temperatures in the paddock were significantly lower than in the truck. However, they rose only from 24.5C to 26C, remaining in a thermo neutral zone, where the deer were unlikely to have suffered from heat stress. This explains why the provision of water-cooling during transport had no significant effect on mean T_b. During yarding and loading instead mean T_b increased (+0.7C to 38.7C), peaked during the start of the journey (further 0.5C) and than declined and remain constant (38.8C) through transport. At unloading it increased again, than declined during the first hour in the paddock (Matthews et al., 2000).

10.13. Driving

Transport companies and driving techniques significantly influenced bruising rate in deer slaughter in a commercial plant (Jago et al., 1996).

10.13.1. Position in the vehicle/orientation and front/rear

The preferred orientation during transport of deer has been investigated in several studies, with similar result. In the transporter, at the space allowance of 0.74 m^2/red deer hind, the animals tended to align themselves parallel and facing the direction of travel, avoiding the diagonal orientation (Jago et al., 1993). In a further study, the reduced space allowance of 0.42 m^2/red deer hind seemed to prevent the animals from standing in their preferred orientation, but approximately equal time was spent either in parallel or perpendicular to the longitudinal axis of the vehicle (Jago et al., 1997). However, diagonal orientation tended always to be avoided. These results are in agreement with the studies of Grigor et al., (1995b; 1998a; 1998d), carried out with similar space allowances (males: 0.5m^2 or 1 m^2/deer, females: 0.4 m^2 or 0.8 m^2/deer) (Grigor et al., 1995b; 1998a) (0.8 m^2/female yearling red deer) (Grigor et al., 1998d), but with stationary and moving vehicle for three hour (Grigor et al., 1998a) or with 3h vs 6 h transport on straight or winding roads (Grigor et al., 1998d). In both studies, independently from treatments, most common orientations were either parallel to, or perpendicular to the direction of the travel, while diagonal orientations were rare (Grigor et al., 1998a; 1998d).

The position within the transport crate was found to play a role in transport stress response (Waas et al., 1999). During transport, higher heart rate and plasma lactate concentrations were recorded in the deer occupying the back of the crate compared to those in the front, probably reflecting greater difficulties in maintaining balance. It might be expected that the back of the crate would swing or move more, leading to higher levels of exertion and/or a psychological reaction to exaggerated and unpredictable movements (Waas et al., 1999).

10.13.2. Rest periods

No scientific information is available on the effect of resting periods during the journey on the response to transport stress in deer.

10.13.3. Feeding and watering

Withdrawal of food and water (20 hours) has been shown to increase subsequent drinking activity in red deer (Hargreaves and Matthews, 1995). Transport time had effects on feeding behaviour: deer spent more time eating after a 6-hour journey than a 2-hour one (Grigor et al., 1998d). According to Grigor et al., (1998a) deer continue to eat during transit if there is sufficient space to do it, and tend to increase lying with transport time. Deprivation of food and water, in deer confined at low space allowance, for 3 or 6 hours, did not induce significant changes in measures of dehydration immediately after the treatment period, but these significantly increased during the recovery period, probably as a result of ingestion of dry feed, as this caused water to move from the body to the rumen (Grigor et al., 1997a). In contrast, a protracted lairage period (9 days *vs* 3 days) was associated with a reduction in urinary osmolality, serum sodium levels and sodium fractional clearance, suggesting the possibility of a recovery of the animal's water-electrolyte balance during the 9 days of the lairage (Diverio et al., 1996b). However, even after 18 hours lairage time, almost no drinking was observed (although this may due a behaviour sampling artefact), and no physiological signs of dehydration were recorded (Grigor et al., 1997b). Although deer were observed eating throughout the lairage time, they progressively lost live weight, suggesting that the amount of straw or hay consumed was very small (Grigor et al., 1997b). In deer, as in other ruminants, the rumen may act as a reservoir of nutrients in water (Fletcher, 1988; Warris, 1990) maintaining water balance and reducing the effects of short-term water or food deprivation (Grigor et al., 1997b). Although it is recognised that a period of lairage may help to reduce gut fill, thus possibly improving slaughter management and hygiene, being in an unfamiliar lairage environment has been recognised to be a stressful experience for deer (Grigor et al. 1997b; Diverio et al., 1996b).

10.14. Lairage

In order to safeguard deer welfare, it is recommended to slaughter deer as soon as possible after they are unloaded from the transporter on the arrival to the abattoir (MAFF, 1989b). The effect of duration of lairage (3, 6 and 18 hours) following transportation (1 m^2/deer space allowance) was studied in yearling male red deer (Grigor et al., 1997b). In the initial period of lairage deer have been observed to spend more time in standing and alert behaviour, remaining in close proximity to each other, and reducing lying and ruminating (Grigor et al., 1997b). There was a tendency for alert behaviour to decrease with lairage, suggesting that deer gradually became accustomed to the new environment (Grigor et al., 1997b). Agonistic activity progressively increased with lairage (Grigor et al., 1997b). A mean of 4 fights/hour, primarily involving biting, was observed during overnight lairage in a commercial abattoir (Pollard et al., 1998). Lairage caused a progressive loss of live weight, but hot carcass weight was unaffected, suggesting that this effect was mainly attributed to the loss of gut content (Grigor et al., 1997b). Different lairage times had no effect on a range of blood variables (PCV, osmolality, cortisol, β-endorphin, NEFA, total protein and sodium), as well as on skin damage, bruising or muscle glycogen content, although liver glycogen content was significantly higher after overnight lairage (Grigor et al., 1997b). Deer slaughtered after overnight lairage showed significantly reduced serum CK levels, compared with those slaughtered immediately after loading, suggesting a recovery from the physical effort associated with handling and transport (Grigor et al., 1997b). In some occasions, overnight lairage resulted in increased bruising rates and subsequent downgrading of carcasses (Jago et al., 1996).

Transport and lairage conditions resulted in poor welfare also in fallow deer, which showed higher cortisol, glucose and CK responses compared to those shot on the field (Diverio et al., 1998b).

According to Australian, Canadian and New Zealand Reports (Tuckwell, 1995; New Zealand Animal Welfare Advisory Committee Codes, 1994; 1996, CARC, 1996) at the abattoir, during lairage, deer should be subjected to fine mist spraying. In fact, mist washes are thought to settle and cool the deer, so they became easier to handle and move through the handling system (Tuckwell, 1995). Pollard et al., (2002) suggested, "Mist spraying also softens dirt, reduce dust and avoid a build up of faeces on the floor".

The proximity of other farmed species in the slaughter plant has also to be considered. In a study of the behavioural responses of farmed red deer within a simulated abattoir, red deer stags chose, in descending order of preference, to be penned adjacent to an unfamiliar deer, nothing, sheep, and last equal, cattle and pigs (Goddard and Abeyesinghe, 1997). According to Pollard et al., (2002), improvement of pre-slaughter stress should be considered as high priority research area.

10.15. Diseases

Farmed deer are susceptible to a range of potential fatally diseases, which may be precipitated by stress, such as malignant catarrhal fever (MCF) and yersiniosis in red deer, or predisposing deer to parasitism, such as chronic wasting disease in wapiti (Mackintosh, 1998). In New Zealand, the occurrence of outbreaks of tuberculosis (TB) has often been related to poor management, low productivity and stressful conditions (Mackintosh, 1998). Capture or transport stress play an important role in the development of post-capture myopathy, characterised by "ataxia, wry neck, paresis and paralysis, with the excretion of brown urine" (Basson and Hofmeyr, 1973; Spraker, 1982; McAllum, 1985), particularly in individuals which are "stress prone", very flighty or aggressive, who rarely survive (Mackintosh, 1998). Increases in muscular serum enzymes activities, indicative of physical stress and overstraining, as recorded after handling in farmed deer (Zomborszky et al, 1996; Carragher et al, 1997), has been suggested to represent a predisposing factor (Harthoorn, 1982).

If the stress is severe, the excessive secretion of cathecholamines can lead to a haemorrhagic enteropathy, ulceration of abomasums and duodenum, or to malignant hyperthermia, where the animal usually dies within 30 minutes of capture (McAllum, 1985; Fowler, 1986; Pingard and Brelurut, 1998; Mackintosh, 1998). To prevent this, minimising stress is a crucial component, especially while yarding, transport and in lairage (Mackintosh, 1998). It is important to remember the zoonotic risks associated with some diseases whose deer can be a vector, such as TB, yersiniosis, leptospirosis, brucellosis, E.

Coli 0157, parapoxvirus, Lyme disease, and there are suspicions for toxoplasmosis, cryptosporidiosis, listeriosis, antrax, rabies, tularaemia and Q fever (Mackintosh, 1998).

10.16. Post-mortem indicators of stress

It is well known that prolonged muscular contraction and glycogen reserve depletion, resulting in increased pH 24 hours post slaughter (pH_u), are predisposing factors for the development of meat quality defects, such as dark firm dry (DFD) meat (Spraker, 1982; Monin, 1988; Pollard et al., 1999; Pollard and Wilson, 2002). A pH_u above 5.8 is a cause of concern when deer are transported since it indicates pre-slaughter stress and it has profound effects on meat quality. Meat with very high pH_u (<6.0) has higher bacteria counts, and approximately half the shelf-life (Stevenson-Barry, 2000). Dark cutting appearance was found in the muscle of stags and castrated deer which had muscle pH_u over 6 (MacDougall et al., 1979). Hinds were found to have a significantly lower muscle pH_u compared with stags or castrated deer (MacDougall et al., 1979).

Higher levels of plasma cortisol, associated with increased pH_u (>5.74), were recorded in farmed red deer captured and transported to a commercial abattoir compared with those slaughtered on farm or shot in the field (Smith and Dobson, 1990). In a survey carried out at a New Zealand South Island deer slaughter plant, a pH_u >5.8 in the *M. longissimus dorsi* was found in approx 70% of fallow deer and 10.6% of red/wapiti animals (Pollard et al., 1998).

A positive relationship between bruising and pH_u was observed (Pollard et al., 1998). Another survey carried out in 1988-1989 established that wounds, bruises and related lesions were a major cause of downgrading and led to significant economic losses (Selwyn and Hathaway, 1990). Bruising received during transport may be a consequence of movements caused by fatigue and stress during the journey (Jago et al., 1997). Rate of carcass bruising has been used as an index of pre-slaughter stress in deer (Jago et al., 1993), as well as of poor handling, management and transportation (Selwyn and Hathaway, 1992). Hindquarters or hocks are usually mainly affected (Jago et al., 1996; Pollard et al., 1998). Jago and Matthews (1998) found that carcass bruising was positively correlated with plasma enzymatic activities (CK, AST, LDH, LDH3, LDH4 and LDH5) in transported deer.

Over a three-year survey at a deer slaughter plant, downgrading due to bruising did not vary significantly, ranging from 6.1% to 7.9% (Jago et al., 1996). Males were significantly more affected than females, and increasing downgrading of stags during the rut appeared to be great. A higher rate of bruising was reported in leaner animals. Increased bruising was significantly related to different farms and carrier companies, poor driving techniques and road conditions, increasing journey length, and sometimes, with overnight lairage (Jago et al., 1996; Pollard et al., 1998).

Ecchymosis (blood splashes) in fallow deer carcass involves economic losses due to the down grading of high value venison cuts, but are an effect of slaughter, in particular of stunning (Falepau and Mulley, 1998).

10.17. Mortality rates

No scientific information is available on mortality rates related to transport in deer. In the beginning of deer farming, in order to minimise stress due to handling and transport, a mobile slaughter unit was used (Seamer, 1986).

11. TRANSPORT OF REINDEER

11.1. Introduction

Reindeer are found in the Northern hemisphere and are particularly adapted to the weather conditions found in the extreme north. They are semi-nomadic, moving from winter quarters to summer grazing to take advantage of plant growth in the northern summer. Reindeer show a different fibre type composition in muscle compared to domestic ruminants and have a large proportion of IIb fibres (Kiessling and Rydberg,, 1983; Essen-Gustavsson and Rehbinder, 1984). These IIb fibres are both highly glycolytic and remarkably oxidative, providing the reindeer with both speed and endurance to escape predators. Reindeer have their main energy reserves in the protein stores in muscle (Kiessling and Kiessling, 1984; Kiessling K-H. and Rydberg, 1983) and have a cyclic pattern of weight reduction in sinter and compensatory growth in summer (Reimers, 1997). This means that during winter they can have depleted glycogen stores, and hence are susceptible to the development of dark, firm, dry (DFD) meat after slaughter, unless they receive supplementary feeding (Wiklund et al., 1996a).

Reindeer have long been domesticated and an intimate part of indigenous cultures but nowadays most reindeer are raised extensively and are gathered, often over several days, during the autumn when they are in best condition. After gathering, reindeer for slaughter are then selected from the mustered animals and can either be slaughtered immediately or fed for a time before dispatch. Traditionally, reindeer were slaughtered at the site of selection but the implementation of new legislation in Sweden regarding meat inspection means that many reindeer are now transported to slaughter often over long distances (Malmfors and Wiklund, 1996, Skoglund, 1997).

The production of reindeer meat is not inconsiderable e.g., Sweden slaughtered 1,300 tons in 2001 (Swedish Agricultural Statistics, 2002), and Finland, about 2,000 in the same period (Kemppainen et al., 2002) and Norway 1.509 tons in 2001 (Forsell, 2002). Average slaughter weights are about 20 kg for calves and about 30 kg for adults.

11.2. Pre-transport handling

There is no doubt that catching and handling is stressful for reindeer. Rehbinder and Edquist (1981) showed that plasma cortisol, urea and ASAT (aspartate aminotransferase) all increased significantly on moving reindeer continuously around a corral for two hours or on subjecting them to the traditional catching procedure of lassoing and that values were much higher than in unstressed animals shot in the field. Manual catching of reindeer did not affect final pH values but plasma cortisol is elevated showing that this procedure is also stressful for the animals (Wiklund, 1996). The most common means used for gathering and herding reindeer are helicopters, snowmobiles (in winter), motorbikes, dogs and horses often more than one means being used at one time (Malmfors and Wiklund, 1996). Provided that the herding method is used appropriately, i.e., according to the environmental conditions, such as snow cover, temperature, insect harassment etc., there are no negative effects on glycogen stores. Wiklund et al., (1996b) showed that a 3-day helicopter drive at 20 km/day, which allows the reindeer to graze on the journey, did not affect glycogen stores or final pH values significantly. However, Rehbinder (1975) showed that gathering reindeer during hot summer days led to considerable calf mortality and as calves were also found to be most susceptible to glycogen depletion (Wiklund et al., 1995), special care must be taken with this category of reindeer.

Reindeer transported immediately after gathering and selection can show very high pH values after slaughter. Wiklund et al., (1995) showed that 31.3% of reindeer gathered by helicopter over at least a 10 day period and subsequently transported 300 km showed DFD meat in the longissimus dorsi muscle after slaughter, DFD being defined as pH values ≥ 6.2. The corresponding values for reindeer kept for a time before transport varied from 3.5 to 8.4%, all depending on category. Wiklund et al., (1996a) also showed that animals in poor nutritional condition also showed higher pH values after slaughter compared with animals that had had supplementary feeding to improve their condition. It is therefore important to allow reindeer to recover from the gathering process before further transport begins and that animals in poor condition are fed for a period before transport occurs.

11.3. Loading

The method of catching reindeer is important and manual handling (catching with lassoes or manual catching) results in struggling animals which can seriously injure themselves. The selected animals can be herded onto the vehicle without restraint (Wiklund et. al., 2001). Manual handling and restraint have been found to cause severe muscle glycogen depletion in reindeer (Essen-Gustavsson and Rehbinder, 1984). Andersen, 1978, remarked that non-slippery and even surfaces during catching were very important to avoid injury to the animals and recommended that reindeer for slaughter be collected in a group the day before transport, so that it would be easier to move the animals towards and onto the vehicle. Reindeer show the same stress response to loading, as do farm animals. Using pre-programmed automatic blood sampling equipment, Wiklund et al., (2001) showed that cortisol increases during herding and loading. There are no publications regarding optimal loading facilities for reindeer but it can be assumed that they need the same conditions as sheep and goats.

11.4. Transport

After loading, cortisol levels decrease as the reindeer gradually calm down as transport progresses (Wiklund et al., 2001). However, average cortisol levels were independent of whether reindeer were transported or not. The authors speculate that the large variation in cortisol was due to individual reaction and may have been affected by the protection offered to some of the animals by the walls of the vehicle. Serum ASAT and urea increased significantly in transported reindeer compared with non-transported animals and this was interpreted by the authors as an indication that reindeer are physically stressed by transport. This physical stress does not necessarily have implications for ultimate pH after slaughter, as another experiment showed that transport up to 1000 km did not lead to any increase in ultimate pH in bulls and calves, although cows did have a slight increase in ultimate pH when transported more than 500 km (Wiklund et. al, 1995). There are limits to transport distance, however, when no feed is offered, and mortalities of up to 25% were observed for transports of reindeer from Russia to Norway (Anon, 1999).

11.5. Stocking density

According to Skoglund (1997) reindeer do not lie down during transport but maintain a stance with legs at an angle and heads held low, using these as a balance pole. This means that reindeer need more floor space than might be expected from their body size. Andersen, (1978) stated, however, that there was a difference in posture during transport and that this depended on sex. Females lay down before males, thus increasing their risk of being trodden on and it was recommended, in addition, that the sexes be separated during transport. Adult reindeer can have antlers and this will also affect space requirements, as well as grouping on the vehicle.

There are no studies on the dimensions of various reindeer categories for transport but it is stated in Annex 9 of a Swedish report on Animal transport (SOU 2003-6) that reindeer vary from 120 to 220 cm in length and are 87-140 cm tall at the withers. There are no studies on optimal stocking densities for reindeer either but Andersen, (1978) showed that with careful loading, bruising was reduced to 4% from 13% when reindeer were transported at 0.7 m^2 per animal as against 0.5 m^2, whereas with less than optimal loading facilities and transport at 0.6 m^2 or 0.5 m^2 per animal, the opposite was true (20% to 16%). Unfortunately, the author did not mention the size of the reindeer being transported or their previous history.

12. TRANSPORT OF RABBITS

12.1. Introduction

The following information relates to domestic breeds and crossbreeds of the European rabbit (*Oryctolagus cuniculus* L.), including possible *Oryctolagus* crossbreeds with other species of the hare family (Leporidae). Domestic rabbits are farmed worldwide for meat, hair and fur production, and have been reared in cages or other closed areas since the Middle Ages (Löliger, 1992). They are also commonly used as laboratory animals, increasingly as pet animals, and are exhibited at in several European countries (Löliger, 1992). Even though they have been selectively breeding for many years in captivity, several studies have shown that domesticated rabbits maintain a behavioural repertoire similar to their wild counterparts (Vastrade, 1986; 1987; Podberscek et al., 1991a; Gunn and Morton, 1995). Differences occur mainly in flight and vigilance behaviour, but social and sexual behaviour have changed very little (Held et al., 1995). Domestic rabbits are still able to utilise complex environments, so housing in cages is unlikely to satisfy many of their needs to show particular behaviour (Hansen and Berthelsen, 2000).

Rabbits are crepuscular animals, spending much of their time and energy on foraging, mainly at dusk and dawn (Xu, 1996; Lockley, 1961 and Love, 1964, cited by Berthelsen and Hansen, 1999). Wild rabbits are social and inquisitive animals (Huls et al., 1991; Lidfors, 1997), live in social groups (2-10 adult subjects and a variable number of rabbits under 3 months old), and have a linear dominance hierarchy that governs interactions among does (Vastrade, 1984; 1986. In free-ranging rabbit colonies the male hierarchy seems to be correlated with area whereas females share their smaller 'home range' with other females (Vastrade, 1987). During the establishment of a hierarchy the does may attack, bite and chase each other or engage in brief fights, but once the hierarchy is established, aggression is markedly reduced. Held et al. (1994) found that, although aggressiveness was rare in groups of does, it can become relevant when living space and flight distance are limited, particularly for low-ranking animals which cannot withdraw when attacked. In a farming situation, when given a choice, rabbits preferred to be in the same cage with other rabbits (Huls et al., 1991; Hafez, 1975). However, they tend to fight with the same sex, particularly males, both for sexual and territorial possession (Xu, 1996). In this regard, scent marking the environment by chemical secretions (pheromones) plays an important role (Xu, 1996). In semi-natural conditions, this behaviour seems to be strictly related to sexual maturity, since males did not display sexual behaviour before 70 days (Lehman, 1991). Aggression is not confined to males and in group housed female laboratory rabbits, aggression can occur during, and after, the establishment of dominance hierarchies, and also in association with sexual behaviour (Held et al., 1994). Aggressiveness can vary considerably between seasons and days, as well as between groups and individuals, but low-ranking animals tend to receive more attacks than the others (Held et al., 1993). However, outcomes of preference tests showed that laboratory low-ranking rabbits did not always avoid potentially stressful group-pens if given the choice to stay in solitary compartments, suggesting that social interactions were still a strong attraction (Held et al, 1995).

Alarm responses depend both on genetic characteristics and on previous experience, since learning can modify subsequent behavioural responses to the same stressor. A characteristic rabbit alarm signal is 'thumping', a rapid movement of the hind legs on the ground, which produces noise (Hansen and Berthelsen, 2000). In a comparative study of caged and floor pen reared rabbits, floor pen reared rabbits showed more freezing and less explorative behaviour compared with those that had been caged (Ferrante et al., 1992). This was thought to be because floor pen rabbits had a higher degree of adaptation due to their experience of an environment that was more akin to the wild (Ferrante et al., 1992). In a study on the effect of environmental enrichment on caged rabbits, no differences in escape reactions between rabbits reared in a conventional or an enriched cage system were found (Hansen and Berthelsen, 2000). However, enriched cage rabbits showed a lower frequency of timidity when captured, less stereotypic behaviour, and higher 'bounding' (moving upwards or forwards with all feet from the floor) (Hansen and Berthelsen, 2000). As a response to stress, rabbits showed increased restlessness, i.e. interrupting their behaviour more frequently and not completing ongoing activities (Lehmann, 1987; Metz, 1987; Hughes and Duncan, 1988). Furthermore, several kind of abnormal behaviours, such as bar-chewing or net-gnawing, excessive grooming, and stereotypic activities such as hair-chewing and licking, head swaying and pawing, feet beating or scratching in a cage corner can develop (Stauffacher, 1992; Morton et al., 1993; Love, 1994, Gunn and Morton, 1995; Hansen and Berthelsen, 2000). The frequency of these abnormal behaviours can be reduced by environmental enrichment (Lidfors, 1997; Berthelsen and Hansen, 1999).

12.2. Rabbits can show aggressive behaviours if their hierarchy is disrupted. Isolation and mixing

Rabbits need to scent mark their territory, which seems to be more important in providing a familiar environment rather than as a signal to repel intruders. An aberrant behaviour noted was that caecotrophs were voided but not re-ingested (Mykytowycz, 1973). Therefore, according to Jolley (1990), “It seems reasonable to assume that being placed in a clean transport crate, or one with unfamiliar odours, is a stressful experience for the rabbit”, as well as “mixing with rabbits from different fattening cages, when a new social hierarchy will not be established”.

C: Aggression can occur between animals regardless of the system of husbandry and may occur when mixing animals in preparation for transport.

12.3. Animal preparation (loading and unloading)

Rabbits destined for slaughter are generally transported on vehicles in plastic travel crates (60cm wide, 30cm high and about 100cm long) provided with loading doors (Leoni et al., 2000), and stocking density can vary up to 16 animals/crate, according to body weight (size), journey length and season (in the summer loading densities are usually lower) (Leoni et al., 2000). According to Jolley (1990) crating could have the potential advantage of being less stressful for loading and unloading than handling animals individually.

Loading can be carried out in one of two ways: in transport crates filled on the farms, or collecting and placing, even throwing, animals into crates fixed on a truck (Mourisse, 1999) . Rabbits on the upper truck levels are often subjected to a greater number of falls (Mourisse, 1999) than on lower levels. In a comparative study of these two different loading methods, Fenelap (National Federation of the Rabbit Farmer Associations) showed that rabbits loaded into fixed crates had a reduction of 0.44% of carcass quality compared with those crated on the farm (Ouhayoun, 1992).

Unloading is carried out by stacking the travelling crates in designated areas in an abattoir, where the animals can be subjected to ante-mortem inspection before slaughter. During lairage, rabbits can be exposed to inadequate environmental conditions, and they are very sensitive to sudden changes in temperature and humidity, presenting problems at humidity levels <55%, and at temperatures less than 5C or greater than 30C (Leoni et al., 2000).

C: The method of loading can affect carcase quality.

C: Lairage conditions can affect rabbit welfare.

12.4. Journey management

Jolley (1990) has reviewed the effects of different aspects related to transport on the welfare and meat quality of farmed rabbits. He pointed out that since in UK “there are few slaughterhouses for rabbits, these animals may spend considerable amounts of time in transit between farm and place of slaughter”. He found in a British Commercial Rabbit Association survey (Anon, 1987) that 43% of rabbits experienced typically a “two stage” transport process, where individual producers take their stock to an intermediate location where the rabbits wait for collection and transport on to a processor. At these stages, a number of potential stressful factors have been highlighted (see Table 12.4.1.).

Table 12.4.1: The two-stage transport chain typical of commercial practice

Location	Event	Stressor
Farm	Preparation for embarkation	Handling Food withdrawal Water withdrawal
	Crating	Separation from family unit, may include weaning stress Mixing Unfamiliar environment
	Transport	Movement and noise Temperature and humidity changes Unfamiliar environment
Collection point	Stacking of crates	Unfamiliar environment
	Transport	Movement and noise Unfamiliar environment
Processor	Stacking of crates	Unfamiliar environment Distress signals
	Slaughter	Handling Stunning

(from Jolley, 1990)

Transport and slaughter methods were shown to influence both rabbit welfare and production negatively (Luzi et al., 1992; Dal Bosco et al., 1997). These operations caused adverse changes in a range of physiological parameters suggesting they represent a severe stress for the animals, independently from their rearing system (Canali et al., 2000). For example, it was found at slaughter that after 6 hour transport by road, plasma cortisol levels were five-times higher than pre-transport, along with increases in blood glucose, CPK, AST and LDH activities, probably as a consequence of the physical stress of transportation. However, significantly higher CPK levels were observed in caged rabbits compared with those reared in a pen. Transport might, therefore, produce a more detrimental effect in rabbits that had been closely confined so preventing daily exercise and the expression of some natural behaviour, such as assuming an erect posture and running (Canali et al., 2000). Their behavioural response to stress, with the flight-fight response being inhibited, may have resulted in prolonged isotonic contractions, a condition which has been shown to predispose to muscle damage (Spraker, 1982).

Animal preparation and handling

Short (1967) underlined that “Correct handling is essential to produce tameness in the animal” and that “Handled animals should always be made to feel secure; they should be held firmly but not tightly. If an animal feels insecure or uncomfortable it will struggle to get free and in doing so becomes difficult to control”. Poor handling can result in injury to the rabbit that may require it to be killed, and it could also cause quite serious injuries to the operator such as scratches and bites (Scobie-Trumper, 1995). Usually rabbits are very tame and frightened of human beings, and they may show a nervous aggression. Signs of aggression in rabbits include: grunting, growling, using the front feet to scratch handlers, and biting. Accordingly, there are three important points to remember before handling.

1. The rabbit has very powerful legs and long sharp claws which can inflict bad scratches on the operator.

2. Rabbits commonly suffer fatal back injuries from incorrect handling or falling.

3. Operators should always wear overalls with long sleeves to cover the arms and wrists, and remember to keep the face away from the rabbit even when it is restrained.”

Recommendations for handling laboratory rabbits, such as how to lift a rabbit from a cage and for sexing, or how to restrain or carry it, have been described and these may also apply to farmed or pet rabbits (Short, 1967; Scobie-Trumper, 1995).

Little research has been done on the human-rabbit bond, and most of it has dealt with the effects of early handling (Podberscek et al., 1991b). Repetition of handling trials showed that both caged and pen reared rabbits adapted quickly to a positive interaction with humans, reducing their level of fearfulness (Podberscek et al., 1991b). Morera et al. (1991) observed increases of body temperatures in response to heat stress in rabbits, which were significantly higher (+ 0.4C) in subjects handled for the first time compared with trained ones. Early handling of rabbits (from birth to 3 weeks of age) reduced fear toward humans, probably through habituation (Metz, 1983/1984; Kersten et al., 1989).

C: Positive interactions with humans at an early stage in life can reduce their level of fearfulness.

Travel times

A survey carried out in the North of Italy over one year looked at transport distances of 25, 50, 100 and 150km in intensively farmed rabbits (Luzi et al., 1992). Carcass yield seemed not to be influenced by distance whereas body weight losses were highly correlated with both increasing travel times (from

1.4% for 1 hour transport to 4.6% for 7 hours) and inside truck temperatures (from 1.5% at 0-6C to 3.8% above 9C) (Luzi et al., 1992; Crimella et al., 1991). Season had no effect but this may be due to the fact that transport was always carried out at night, and so differences in environmental temperatures were not extreme (Luzi et al., 1992; Crimella et al., 1991). The most critical conditions seemed to stem from night temperatures above 18-20C, with a relative humidity of 70-75%, transport times over 4 hours, and distances above 100km (Luzi et al., 1992).

Even short journeys of 2 hours significantly increased body weight losses (1.76%), but these were moderate compared with those reported in other studies (about twice as high in Masoero et al., 1992; and almost three times higher in Ouhayoun and Lebas, 1995, Dalle Zotte et al., 1995). These losses probably reflected gut fill loss since dressed carcase weight was not affected. Short transport times also influenced the physico-chemical and sensory properties of the meat with muscle pHu significantly increased from 5.71 to 5.86. In addition, cooking losses decreased, meat colour was darker but meat tenderness was higher (Dalle Zotte et al., 1995).

Ashby et al., (1980), Purdue (1984) and Coppings et al., (1989) carried out a number of experiments on the effects of different periods of feed or water withdrawal up to 24 hours before transport and slaughter. The details of these studies have been summarised and compared by Jolley (1990). The major outcomes underline the difficulty of differentiating the effect of transport on the live weight of rabbits from that of concomitant fasting. For instance, weight losses were higher after 6 hour transport compared with rabbits fasting for the same period. However after 24 hours the fasted animals lost more weight than those transported (Purdue, 1984). These apparently contrasting results may be mainly due to changes in gut fill, which are influenced by water and food withdrawal as carried out pre-transport (Jolley, 1990). However, Purdue (1984) reported that tissue fluid losses were enhanced in transport, since the proportion of total body weight loss was higher than that related to changes in gut fill. Furthermore, transport slowed down the reduction in gut fill in rabbits that were allowed feed prior to transport compared with fasting alone (Purdue, 1984).

Neither heart or kidney weights were affected by fasting or transport (Coppings et al., 1989) whereas liver weight decreased with time. The effects of water or food deprivation and transportation on liver glycogen concentrations were more complex. Jolley (1990) summarised the major outcomes: liver glycogen concentrations decreased rapidly after 6-12 hour fasting; water availability influenced liver glycogen concentrations as did plasma glucose concentrations.

Ouhayoun and Lebas (1995) found that transport elicited a more pronounced response to stress than fasting alone, and that the length of the journey influenced the metabolic changes. In fact, pH_u in the *Longissimus dorsi* and *Biceps femoris* was 0.2 units higher after a longer journey (250 km *vs* 30 km), as a consequence of depletion of muscle glycogen (Ouhayoun and Lebas, 1995). However, after an 18-hour resting period the muscle pH_u fell from 5.81 to 5.72 following mobilisation of liver glycogen (Ouhayoun and Lebas, 1995). A significant reduction of muscle glycogen reserves was also observed after a 24-hour journey, as glucose dropped from 15.5 to 8.23 μmoles/g muscle tissue (Jolley, 1990). Transport (either 6 or 24 hours) increased the depletion of muscle glycogen more then fasting alone, independently of whether the animals had been fed before the journey (Purdue, 1984). This condition led to raised pH_u (6.27 *vs* 5.90) and water-holding capacity, decreased lightness and colour saturation and drip losses. Such changes have been observed as dark, firm and dry meat (DFD), (Hulot and Ouhayoun, 1999). According to Masoero et al., (1992) and Xiccato et al., (1994), two hours in the lorry are enough to cause a significant rise of pH_u.

Changes potentially leading to pale, soft, exudative (PSE) meat, characterised by low pH_u, have been registered in the rabbit, but these seem more related to the amount of activity immediately before and after stunning, such as violent struggles following decapitation (Bate-Smith and Bendall, 1949). However, no specific studies have been carried out on the effects of transport. According to Jolley (1990) even if rabbits incline to PSE, this is unlikely to be a commercial problem because some degree of paleness is a positive attribute for rabbit meat. However, Jolley (1990) underlined that, even in the rabbit, the presence of low pH_u has to be considered a potential indicator of stress, and can be used to identify welfare problems related to transport operations. Rabbit muscle pH and related traits have been reviewed by Hulot and Ouhayoun (1999).

12.5. Space allowance

Transport by road

No scientific data are available on experiments carried out on the effect of space allowance during transport on rabbit welfare. On the other hand, the incidence of stocking densities in different farming systems has been studied (Coulmin et al., 1982; Maertens and De Groote, 1984; Mourisse and Maurice, 1997; Mourisse, 1999). In male and mixed-groups of fattening rabbits, the frequency of aggressive encounters increased with group size. In groups with 10-15 animals it was significantly lower than in groups of 16-30 or $\geq$ 40 animals (Bigler and Oester, 1996). High stocking densities in housing systems (from 40 kg/m^2) were found to negatively influence rabbit performance, leading to problems such as fur plucking and ear biting (Maertens and De Groote, 1984). The composition of the social group and the space available for each animal has been shown to affect also rabbit behaviour (Mourisse, 1999). An increase of stocking density, from 15.3 to 23 $rabbits/m^2$, reduced social interactions and locomotory activities and increased self-directed activities in growing fattening rabbits (Mourisse and Maurice, 1997). No increase in agonistic behaviour was found in relation to stocking density probably as dominance and sexual behaviour leading to aggression is uncommon in rabbits slaughtered before sexual maturity. These findings seem to confirm that rearing young rabbits in mixed sex groups can be carried out without a major problem (Mourisse and Maurice, 1997). Scientific results suggest that cage stocking density in farming conditions should not exceed 40 kg/m2 (Maertens and De Groote, 1984; Mourisse and Maurice, 1997) and this is in agreement with the space allowance recommendations for rabbit housing given by the German Group of the World Rabbit Science Association (1992), as described in Löliger (1992).

It should be noted that motivation for space may be very important for rabbits, since they will work hard to access a large area (0.315 cm^2) (Bessei, 1997; cited by Morisse, 1999).

Some indication of the space allowances in use for rabbit transport can be obtained from information derived from the commercial practices. Rabbits are usually transported in large vehicles (carrying up to 3000 animals). The number of rabbits loaded into a commercial crate (60cm x 100cm, 30cm high; Leoni et al., 2000) varies according to animal weight (from 13-16 rabbits/crate for 2-2.2kg rabbits, to 10-12 rabbits/crate for 2.6-3.0kg rabbits), and season (or ambient temperature), when the number is reduced to 10-11 rabbits/crate in the summer, even for the lighter rabbits. Crates are usually packed in such a way as to leave an internal area for improved airflow to the central area of the vehicle

If we analyse data from commercial practice, the best condition was 10 rabbits/crate with a space allowance of 0.06 m^2/rabbit. This area represents less than a third of the minimum floor space allowance recommended for rabbit farms (0.20 m^2 for rabbits up to 4 kg/lw) by the German Group of the World Rabbit Science Association (1992, in Löliger, 1992).

C: No scientific data are available on experiments carried out on the effect of space allowance during transport on rabbit welfare. However, from space allowances for commercial practice it would appear that a space allowance of m^2/rabbit/crate would not be unreasonable. This density may have to be reduced in hot conditions (i.e. above 18-20^{o}C).

Transport by air

Air cargo is rapidly increasing as a mode of transport and so control of temperature, relative humidity and ventilation rates are crucial factors. Only one study has been specifically focused on heat and weight losses of rabbits during simulated air transport (Ashby et al., 1980). They found that heat production after 48 hour fasting subjected to simulated transport at 21C, averaged about twice the basal rate. In particular, the restricted activity in the crates and the fasting apparently reduced the heat loss to about 40% less than unstressed subjects (Ashby et al., 1980). Weight loss after 48 hour fasting and transport was 10% and the rabbits required about 42 hours to regain their original weight, but 75 hours were needed before they returned to their normal growth rate. Equations for predicting heat and weight loss were calculated.

C: Air cargo is rapidly increasing as a mode of transport and so control of temperature, relative humidity and ventilation rates are crucial factors.

Floor type

Rabbits panic if placed on a smooth surface, preferring to be placed on rough material where they feel more grip, for example towelling, sackcloth, wire mesh (Scobie-Trumper, 1995). Smooth floors may also prevent foot disease such as pododermatitis (Rommers and Meijerhof, 1996). Fattening rabbits kept under intensive conditions preferred a wire floor to deep litter with straw (Mourisse et al., 1999). UFAW (1988) recommend the use of solid floors for rabbit transport crates, in order to prevent contamination with urine and faeces from the higher to lower crates, but spillage may still occur promoting aggression between the animals (Jolley, 1990). Chemical communication plays an important role in rabbit behaviour (Vastrade, 1986; Xu, 1996) and urine marking is a territorial and social display signal in rabbits, so much so that if young rabbits are smeared by foreign urine their mother will attack them (Mykytowycz, 1958). Therefore, Jolley (1990) pointed out that the presence of new olfactory cues during crating and transport will probably induce responses that may vary depending on age and sexual maturity.

C: Flooring type can predispose to aggression and so should be taken into consideration.

12.6. Thermal conditions

The recommendations for ambient temperatures in caged systems are 20C for weaned rabbits and 10 to 15C for breeding rabbits (Bessei et al., 1997). Extreme conditions, such as temperatures above 35C or low humidity (below 55%), were found to be detrimental for rabbit welfare (Lebas et al., 1986).

Several studies have been carried out to investigate the effects of environmental temperature under different farming systems (Chiericato et al., 1994; 1995; Amici and Merendino, 1996) but few have focused on thermal conditions in transport (Ashby et al., 1980; Purdue, 1984) and so those for husbandry may act as a guide.

Rabbits subjected to thermal stress can adopt changes in body position to adjust their heat losses (Jolley, 1990). The rabbit cannot sweat but can pant, and heat can also be lost by vasodilatation in the ears (Gonzalez et al, 1971; Harkness, 1988). Simplicio et al., (1988) observed some variation in metabolic parameters following heat stress conditions. A decrease in Vitamin C was seen one week after exposure at 30±2C (Verde and Piquer, 1986), and the addition of bicarbonate in the diet improved growth performance (Bonsembiante et al., 1989) and was thought to help reverse the metabolic changes caused by panting (Finzi et al., 1986). Rabbits reared under high temperatures (30C, 65% relative humidity) had higher plasma concentrations of cholesterol, creatinine, AST, ALT and chlorine compared with rabbits reared at a lower thermal range (12C, 65% relative humidity) (Chiericato et al., 1994). Rabbits exposed to heat stress (33.5C) showed a significant increase in rectal temperature (1.5C) and plasma levels of Vitamin E, but feed consumption and immunological measures were decreased (Amici and Merendino, 1996). Raised temperatures also (27C) markedly affected nutrient intake, overall growth performance and androgen and thyroid hormones significantly decreased compared with subjects kept under thermoneutral conditions (Chiericato et al., 1995); cortisol plasma levels were not influenced by temperatures between 20 and 27C. On the other hand, animals at lower temperatures showed a marked variation in productivity, presumably because of the need for increased thermogenesis and presumably greater adipogenesis. Rabbits also showed higher feed intakes, daily bodyweight gain and more unfavourable utilization of the feed (Chiericato et al., 1994) . Season and type of housing system also has a significant effect on productivity and meat quality of rabbits (Paci et al., 1999), with higher mortality rates in the summer (11% at an environmental temperature ranging from 18 to 32C) (Paci et al., 1999). There is little information on the rabbit reaction to low temperatures, but practical experience shows that they are quite resistant to cold (Bessei et al., 1997). When rabbits were given a choice of moving between compartments at 10, 15 and 25C, they showed a clear preference for the lowest temperature and that preference increased with age (Bessei et al., 1997).

Rabbits subjected to simulated transport stress significantly increased their respiratory rate, which remained elevated for several hours. It is possible that in transport crates, overcrowding might impede the adoption of thermal adjustment postures and heat dissipation mechanisms, leading to welfare problems. This is particularly critical when crated animals are awaiting slaughter after transport, in poorly ventilated areas, or are not protected from adverse weather conditions (Jolley, 1990). UFAW, (1988) recommended that rabbits should not spend more than 8 hours in the crates, including the transport time.

The rabbit sensitivity to air flow and toxic gases (ammonia) has been studied by Mourisse et al., (1977 and 1978) and high ammonia concentrations (from 20 to 30 ppm) were shown to predispose rabbits to respiratory *Pasteurellosis* (Mourisse et al., 1977; 1978).

C: Few studies have focused on thermal and other appropriate conditions in transport. It is important to avoid extremes of temperatures (e.g. reasonable estimates of acceptable temperatures are likely to be between 10 and 20°C) low air flow rates, and high ammonia levels (greater than 20ppm).

12.7. Feeding and watering

Domestic rabbits have the same rodent type behaviours as true rodents, i.e. when they are not feeding, they often chew the cage, litter box or any materials that have hard, projected surfaces (Xu, 1996). Rabbits carry out caecotrophy ingesting caecotrophs taken directly from the anus. These caecotrophs differ greatly in nutritive composition from the hard ones, which are commonly excreted (Xu, 1996). Caecotrophy is nutritionally important for rabbits as they obtain large amounts of proteins and water-soluble vitamins (B and K) through the action of bacteria in the hind gut (Cheeke et al., 1987). Such recycling of faeces probably provides good protection from starvation and may explain why rabbits are considered to be resistant to such conditions (Lebas et al., 1986; Jolley, 1990). Food withdrawal during transport may prevent caecotrophy and they may find this stressful (Jolley, 1990). However, no studies have been carried out to investigate if overcrowding in transport crates impedes this behaviour (Jolley, 1990). It is well known that caecotrophy stops when a rabbit is sick (Xu, 1996).

Fasting for 12 hours caused a 3-4% body weight loss and after 36-48 hours this had increased to 10-12%, but these losses could be reduced if water was provided (Ashby et al., 1980; Purdue, 1984). High muscle pHu was recorded in rabbits deprived of food for 48 to 72 hours (Bate-Smith and Bendall, 1949). This rise in pHu, from the 24th hour of fasting, was due to depletion of muscle glycogen reserves (Jolley, 1990). According to Lebas et al., (1986) rabbits are very resistant to thirst, since they can survive water deprivation for up to 4-8 days without irreversible damage. The rabbit body contains about 70% water, and is somewhat higher for young animals (Xu, 1996).

When given dry feeds most of their water intake (60%) naturally occurs at night. If water intake was limited to 10 minutes every 2 days, a reduction in feed intake, growth and body weight were observed but this effect was not significant if the water restriction was carried out daily (Xu, 1996). However, this condition has been shown to have adverse effects on milk production by does, and consequently on the suckling pups, particularly when associated with high environmental temperatures (Xu, 1996).

The effects of different periods of water removal (17, 24 and 41 hours), journey length (30 *vs* 250 km) and lairage (after arrival *vs* 18 hours) on rabbit meat composition and yield have been investigated (Ouhayoun and Lebas, 1995). After 41 hours of water withdrawal, weight losses increased by up to 7.9%, whereas carcass yield decreased by 3% (from 60.3 to 57.1%). Longer travel distances and lairage times significantly increased weight losses (from 3.65 to 5.78%), and reduced muscle glycogen reserves and as a result, muscle (*Longissimum dorsi*) pHu at 24 hours increased from 5.56 to 5.69 (Ouhayoun and Lebas, 1995).

C. Rabbits can reasonably withstand food and water deprivation for 24hours without significant adverse effects on bodyweight and carcass quality.

C. Lactating does with litters should not normally be transported.

Diseases

It is currently accepted that digestive pathologies are the most important in young rabbits, while in adult animals respiratory and reproductive pathologies are more frequent (Rosell, 1996). In farm and abattoir surveys, the zoonotic risks associated with *Toxoplasmosis, Chlamydiosis, Salmonellosis, Listeriosis, Staphylococcus and E. coli* infections and dermatomycosis were found (Facchin et al., 1996). Some other diseases of rabbits, such as rabbit viral haemorrhagic disease, can be spread by transport. Deformations of the vertebral column were shown to be dependent on cage size (Drescher, 1996).

C. As with all animals there is potential for the spread of serious diseases by transport.

Mortality rates

No data are available on transport mortality rates in rabbits, but information obtained from commercial practices suggests that mortality rates of between 0.1% and 0.4% occurred when the pre-slaughter fasting period was longer than 12hours (Leoni et al., 2000). Cases of post-transport mortality rates of 7 and 8% have also been reported, particularly if the vehicle was not provided with a controlled air ventilation system. This mortality can rise dramatically when unexpected long stops occur during the journey, e.g. traffic jams. Elevated ambient temperatures and high humidity rates can increase losses even further. Under-graded carcasses represent about 1% and are due to trauma or broken bones. Ferrari et al. (1989) observed a high incidence of traumatic lesions, characterised by subcutaneous haemorrhages caused by loading and unloading for transport. These lesions were mainly leg fractures and bruising which reduced meat gradings (Leoni et al., 2000).

13. TRANSPORT OF DOGS AND CATS

13.1. Introduction

Transport may be stressful for dogs and cats (MacArthur, 1987a; Leadon and Mullins, 1991). However, there is much less information available on the effects of transport conditions on the welfare of dogs and cats than on many other domestic species, particularly farm animals. Further, much of the available information is in the form of recommendations based on practical experience, rather than on controlled experiments. This distinction between practical recommendations and scientific evidence will be made clear whenever possible in this report.

This report focuses on (1) individual differences in responses to transport in dogs and cats, (2) space allowance when animals are transported individually, (3) transport of several animals together, (4) recommendations other than size on the containers used to transport dogs and cats, (4) feeding and watering frequency, (5) animals unsuitable for transport, and (6) inspection.

13.2. Individual differences in response to transport

Individual dogs and cats may differ greatly in their response to stressors and it is likely that this applies to the stress of transport as well. Although part of this individual variability is probably due to genetic factors, habituation, rearing conditions also play a role. There are at least three important issues to consider:

a. There is a "socialization period " in puppies that is very important for the formation of primary social attachments. This period extends for 2-3 to 9-13 weeks of age (Scott, 1962; Scott and Fuller, 1965). This period is relevant here because it is recommended that the puppy should be introduced during the socialization period to the stimuli that it is likely to encounter as adult (Scott and Fuller, 1965), so that it becomes easily habituated to them. Thus, exposing the puppy to the container used for transport before the end of the socialization period may be useful. A similar period has been described in cats and it extends from 2 to 7 weeks of age (Karsh and Turner, 1988).

b. Early handling of puppies and kittens may have beneficial effects on their response to stressors later on in life. Canine neonates exposed to varied stimulation from birth to five weeks of age were found to be more confident when tested later in strange situations than non-stimulated animals (Fox, 1978). Similarly, kittens which were handled for five minutes per day from birth to 45 days of age approached strange objects more readily than controls (Wilson et al., 1965). Thus, although no studies have been done on the effects of early handling on the stress of transport, it seems likely that it may have a beneficial effect.

c. Habituation helps in the management of potentially stressful events in animals and habituating dogs and cats to transport conditions may be useful (Leadon and Mullins, 1991). IATA (2002) recommends that dogs and cats are habituated to the container that will be used for air transport well in advance of the journey. Similarly, habituation to humans is important to avoid fear reactions during transport and handling. Some dogs may benefit from the presence of the owner as this can decrease fear and stress.

13.3. Space allowance when animals are transported individually

Dogs and cats are usually transported in specially designed containers, either individually or –less frequently- in groups. Dogs may also travel loose in small groups in the cargo area of a suitable vehicle (LABA and LASA, 1993)

Individually transported dogs

As it is generally recommended that the container used to transport dogs should be large enough to permit the animal to lie down (see below), it might be useful to know the resting postures adopted by dogs. Dogs may lie down in four different postures (Beaver, 1999): sternal recumbency, lateral recumbency, a combination of cranial sternal recumbency and caudal lateral recumbency, and on their back. When dogs lie in lateral recumbency, legs may be fully extended and the area occupied by the dog will then be equivalent to its length multiplied by at least its height from floor to withers. According to Beaver (1999), lateral recumbency may account for up to 26% of the total lying time, sternal recumbency for up to 20% and the combination of lateral and sternal recumbency for up to 53%.

Recommendations by other bodies are that the container should be large enough to permit the animal to stand in a natural position, turn around and lie down (LABA and LASA, 1993; AATA, 2000).

In several of the available set of recommendations, the size of the container is based on three measurements:

- Height of the animal (H) (from floor to top of the head)
- Length of the animal (L) (from nose to root of the tail)
- Width of the animal (W) (measurement through the shoulders)
- Length of legs (B) (from floor to elbow joint)

The recommended size of the container is then:

- Length = L + 20 cm (AATA, 2000) or L + ½ B (LABA and LASA, 1993)
- Height = H + 5 cm (AATA, 2000) or H (LABA and LASA, 1993)
- Width = W x 2 (LABA and LASA, 1993; AATA, 2000)

The main difference between the two sets of recommendations refers to the height of the container. Although we are not aware of any experimental work addressing this issue, the recommendation of AATA will probably allow for better ventilation. A second issue is that in some cases, none of the above recommendations would allow the dog to lie down in lateral recumbency, as the container should then be wider. This may be relevant because as explained above lateral recumbency accounts for a considerable proportion of the total resting time. However, to the best of our knowledge there is no study on the effects that being prevented from adopting this posture may have on the dog's welfare. Finally, AATA recommendations on extra space (20 cm in length or 5 cm in height) do not take into account differences between dogs in body size. It would be better, therefore, to relate this extra space to the size of the dog. The above recommendations refer to laboratory dogs, i.e. mainly Beagles, that measure between 30-40 cm in height (from floor to the withers, which would be equivalent to some 60 cm from floor to top of the head) and some 60 cm in length (from nose to the root of the tail). Therefore, the recommended space is roughly equivalent to L + 30% and H + 10%.

Individually transported cats

As it is generally recommended that the container used to transport cats should be large enough to permit the animal to lie down (see below), it might be useful to know the resting postures adopted by cats. According to Beaver (1992) there are three basic body postures associated with lying. Sternal recumbency is one of them; the forepaws may be pointed forward or rotated and flexed so that they are tucked back under the cat. A second posture is complete lateral recumbency with the cat either stretched out or curled with the paws folded around one another. Lateral recumbency is associated with sleep; cats may sleep for up to 9-12 hours a day, *i.e.* 40-50% of the total time (Beaver 1992). The posture adopted when in lateral recumbency is affected by ambient temperature and the warmer the environment, the more stretched out is the posture adopted by the cat. The third lying posture is a combination of cranial sternal recumbency and caudal lateral recumbency.

Recommendations given by other bodies are that the container should be large enough to permit the animal to stand in a natural position, turn around and lie down (LABA and LASA, 1993; AATA, 2000). LABA and LASA (1993) recommend containers 52 cm long x 35 cm wide x 35 cm high (in the case of rectangular containers) and 50 cm diameter x 35 cm high (in the case of circular tubs). Hurni and Rossbach (1987) recommend containers of 61-68 cm long x 36-44 cm wide x 40 cm high. AATA (2000) recommends working out the size of the container using the same method as in the case of dogs.

The above recommendations can be divided into two groups: those that take into account the actual size of the cat (AATA, 2000) and those that do not (LABA and LASA, 1993; Hurni and Rossbach, 1987). The obvious problem with the latter is that cats may differ in size. Although the diversity of body size is much less in cats than in dogs, there may still be a large variation. For example, adult, non castrated males may weigh between 3.5 and 7 Kg –and in some cases even more-, depending on body condition and breed, among other things. In principle, then, AATA's recommendations would appear better. Nevertheless, the problem already mentioned for dogs will also occur with these recommendations, as some cats might be prevented from lying down in lateral recumbency with fully extended legs. This might occur, for example, with thin, slender breeds such as the Siamese. Again, to the best of our knowledge, there is no study on the possible effects that this might have on the welfare of the animal.

13.4. Transport of several animals together

Recommendations given by other bodies are that dogs and cats may travel in group only if (1) they are familiar with each other and do not show aggressive behaviour, (2) females are not in oestrus, and (3) none is over 14 Kg bodyweight (AATA, 2000). Following the Animal Welfare Act of the United States Department of Agriculture, IATA (2002) states that only dogs and cats less than 6 months of age, weighing less than 9 Kg and having a comparable body size, can be placed together in the same container for air transport, even if the animals are familiar to each other. The reason for this is that even acquainted animals may become stressed and aggressive when travelling by air (IATA 2002).

According to LABA and LASA (1993), a maximum of 2 adult dogs of comparable size up to 14 Kg each that are compatible with each other may be shipped in the same container. Animals over that weight must travel individually. Animals up to 6 months old from the same litter and up to a maximum quantity of 3 animals may be shipped in the same container. The length and height of the container are determined in the same way as for a single animal, considering the largest animal. The width of the container should be W x 3 (2 animals) and W x 4 (3 animals).

According to Martin (1998), one cat per container is permitted for air travel and up to 4 compatible cats per container are permitted for ground transportation, but no information is available on the size of containers for more than one cat. Hurni and Rossbach (1987) state that containers of the recommended size (see above) can accommodate 1 or 2 cats, that should be of the same breeding group to avoid fighting.

It is well known than dogs and cats may be aggressive towards unfamiliar conspecifics. It seems therefore reasonable that unfamiliar individuals should not be transported together. The problem, however, is whether transporting familiar animals together can be recommended. One problem that must be considered is redirected aggression. A redirected behaviour is a motor pattern appropriate for a motivational state that is directed to an irrelevant but accessible target because the primary target or stimulus is inaccessible (Bastock et al., 1953). Redirected aggression is common in animals and seems to be particularly frequent in cats (Chapman and Voith, 1990). A common situation that may elicit redirected aggression is when a cat is aroused because it is afraid and reacts aggressively towards another cat that is nearby (Borchelt and Voith, 1982). As it is likely that transport may be frightening, redirected aggression may occur even between well acquainted individuals. Therefore, particularly when animals may not be frequently inspected during the journey – as it may be the case, for example, during air transport, it is preferable not to transport several animals together in the same container, with the exception of young dogs and cats.

13.5. Qualities needed for the containers used to transport dogs and cats

Containers used to transport dogs and cats should safely and securely contain the animal or animals. The inside of the container must be free of any projection or object that could injure the animal. Animals must not be able to push parts of their bodies through the sides of the container. Containers should be clearly marked “LIVE ANIMALS” and it should be indicated which side must face up. Also, each container must be clearly marked with the type and number of animals in it, and the consignor’s and consignee’s name, address and telephone. All containers must be secured to the vehicle (Hannah, 1998; LABA and LASA, 1993; AATA, 2000). Bedding should be provided (Hurni and Rossbach, 1987; AATA, 2000)

According to AATA recommendations (AATA, 2000), containers should be loaded in such a way that there is at least 10 cm space between each crate for ventilation. Dog containers should not be stacked more than two high, and cat containers not more than three high. Containers should be mounted on pallets to raise them from the floor. Antagonistic animals should be loaded in such a way that they can not see each other.

It has been mentioned that one difficulty with the size of the container may occur during air transport, when animals are transported in the below-floor cargo section of passenger carrying airlines. The dimensions of the door of this section may prevent the use of containers taller than 86.5 cm (for example in Boeing 737 aircraft) which is less than the height of some dogs (Leadon and Mullins, 1991). It is not clear whether this may cause stress in the animals.

Thermoregulation problems appear to be important welfare problems in the transport of dogs (Laedon and Mullis, 1991) and possibly cats (Martin, 1998). At least in this latter species, cages made from highly insulating plastic material should be avoided, as they can cause overheating (Hurni and Rossbach, 1987).Although there is very little information on the range of acceptable temperatures for dogs and cats, it is accepted that adequate ventilation is important for the welfare of both species. The ventilation system should provide fresh air with minimal drafts (Martin, 1998). For dogs, ventilation is adequate if one whole side of the container be open and consist of bars or wire mesh. In addition, ventilation openings of 2.5 cm over the whole surface of the opposite side at a distance of 10 cm from centre to centre of each opening are needed with similar openings on the upper third of the remaining two sides. The total ventilated area needed a minimum of 16% of the total surface area of the 4 sides (LABA and LASA 1993; AATA, 2000). Similar recommendations are given for cats; Hurni and Rossbach (1987) advise that the total ventilation area should occupy 10-15% of the area of the side. It is important to remember that animals must not be able to push parts of their bodies through the sides of the container. In the case of dogs, different breeds may differ in their susceptibility to heat stress and transport of animals such as boxers, bulldogs and Pekinese when ambient temperatures are high may not be safe, as dogs with snub nose have difficulty in maintaining a normal body temperature in hot weather (IATA, 2002).

13.6. Feeding and watering frequency

According to Mugford (1977), dogs that have free access to food 24 hours a day eat many small meals a day. Rashotte at al. (1984) found that Beagles living in individual kennels with dry food freely available eat at dawn, at dusk and whenever fresh food is offered. This suggests that feeding only once a day is not preferred by dogs.

It is widely accepted that all breeds of dogs descend from the wolf (*Canis lupus*) (see Lindsay, 2000 for a review). Wolves digest food quickly and eat several times a day when large amounts of food are available. On the other hand, however, it is not uncommon for wolves to have to go without food for several days at a time and wolves seem to be well adapted to fasting (Mech, 1970).

Cats eat many small meals per day when food is freely available. This is not surprising considering that that small rodents are the natural prey of cats and that wild or feral cats may kill and eat many mice per day (Houpt, 1998).

The metabolic effects of fasting have been studied in dogs by De Bruijne and Koster (1983). Maximal depletion of liver glycogen occurred between the second and the third day of fasting and starvation-induced glycogenolysis was much slower in the dog than in men and rats. The authors concluded than in the fasting dog larger amounts of glycerol are available for gluconeogenesis than in other species. This may suggests that dogs are more resistant to fasting than other species.

Recommendations given by other bodies are that adult dogs and cats should be fed at intervals of not more than 24 hours (MacArthur, 1987a; LABA and LASA, 1993; Martin, 1998; AATA, 2000). Water should be provided every 12 hours (MacArthur, 1987a; LABA and LASA, 1993; Martin, 1998; AATA, 2000). Water can be provided in spill-proof containers for long journeys (MacArthur, 1987a; AATA, 2000) or the vehicle should be stopped to offer water to the animals. In this case, the animals should be allowed sufficient time to drink; LABA and LASA (1993) recommend 30 minutes for dogs and cats, whereas Martin (1998) recommends 1 hour for drinking twice a day for cats.

Young animals more often, puppies and kittens less than 16 weeks of age at least every 12 hours need food according to Hannah (1998). MacArthur (1987a) recommends that “young” dogs are fed every 8 hours. According to AATA (2000), animals under the age of 6 weeks should be allowed to suckle at intervals of not more than 4 hours (see below).

Dogs and cats are prone to travel sickness and vomiting. LABA and LASA (1993) therefore recommend that the animals are fed a light meal 4 hours before commencing the journey and should be exercised immediately before dispatch to stimulate elimination. AATA (2000) recommends that the animals are not fed for 2 hours prior to dispatch. IATA (2002) advises reducing the quantity of food given to the dog or cat the day before an air transport, leaving water available not taking dogs for a walk before being shipped so that they are allowed to urinate and defecate. A light meal before tendering the animal to a carrier may have a calming effect.

Although it is difficult to critically assess the LABA, LASA and AATA recommendations, it may be concluded that although feeding once every 24 hours is not preferred by dogs, they are relatively well adapted to fasting. One point that should be kept in mind, however, is that dogs differ greatly in body size and small dogs may not be as resistant to fasting as medium or large dogs. Other factors such as body condition, degree of insulation, feeding before transport, and handling before and during transport may also modify the animals’ response to fasting and this should be taken into account. In cats, there is even less information available.

13.7. Transport of young animals, inspection and use of drugs

Young animals under the age of 6 weeks are not generally suitable for transport. If left with their mother there is a risk of accidental suffocation. However, they need to suckle at frequent intervals (see above) (AATA, 2000). Inspection every 4 hours, when temperature, ventilation and general condition of the animals can be checked is important (Hannah, 1998; Martin, 1998). Using drugs when animals are transported by air may be dangerous, as drugs may act differently at the pressure in the cabin and cargo area (IATA, 2002).

14. TRANSPORT OF RODENTS AND PRIMATES

Several of the species which are used in laboratories are mentioned in other chapters of this report, for example rabbits, dogs and cats. However, rodents are not discussed elsewhere so will be considered briefly here.

Primates might be transported for various reasons, especially because they are used in laboratories. A short section from the SCAHAW Report on the welfare of captive primates is reproduced here.

Despite the fact that large numbers of laboratory animals are transported, largely from supply companies to the laboratories where the animals will be used, very few scientific studies provide data of any kind on the effects of transport on laboratory animal welfare. The material presented here is largely derived from guidelines produced as a result of practical experience so less reliance can be placed upon it than on data from scientific research.

14.1. Rodents

The transport of laboratory rodents, particularly the species listed below, is based on practical experience of moving probably millions of animals over several decades. The species about which there is most practical experience are laboratory rats (*Rattus norvegicus)* and mice *(Mus musculus)*. Other rodents are also transported include the guinea-pig (*Cavia porcellus),* the golden hamster (*Mesocricetus auratus)*, and the Mongolian gerbil (*Meriones unguiculatus)*. All of these are quite small or very small mammals, hence they can be transported in cages and other sorts of boxes. These boxes are designed so that gnawing animals cannot escape and are provided with ports that permit ventilation and inspection. The box construction material and the bedding material are non-toxic and non-consumable. Some of the containers are washable, autoclavable and re-usable. With the exception of hamsters that do not normally live in social groups, and male mice of some strains, animals are often transported in breeding pairs or in groups that are familiar with each other. Extreme care should be taken when placing animals in boxes, as well as removing them so that if animals escape they can be easily caught, for example in a garbage bin or hood. Several groups can be transported in one cage or box through the use of cage dividers.

Food and water are supplied as may of these small species require constant access to feed to maintain their body temperature. Food for rodents during transport is normally in the form of dried pellets or in some cases fresh vegetables and fruit (e.g. apples, carrots, potatoes) and, provided that the animals have had experience of such food, these diets are adequate. Food that is likely to decay over a short time should be avoided. Water is commonly provided sometimes provided from agar or as colloidal "gelled water".

Rodents require sufficient space to be able to adopt a comfortable resting position, to groom, to rear up, and to move in general. The stocking densities recommended by the Laboratory Animal Science Association for rodent species given below are based on practical experience. Mortalities can occur from fighting when unfamiliar animals are shipped, or they have been diverted during a flight and kept in inappropriate places at airports. There are different recommendations on stocking densities for filter top transport boxes and those where the circulation is not impeded.

Since welfare during transport will be poor if animals give birth during the journey, it is necessary to know the date of onset of pregnancy and the gestation period, so that the last five days of pregnancy can be avoided (see Table 14.1.1.).

It may be necessary to change some aspects of transport if genetically modified animals or genetic mutants with different needs are transported, for example some mutants are hairless.

Table 14.1.1. Typical gestation periods and latest day for transport .

Species	**Gestation period**	**Last day for transport**
Cat	64-67	42
Dog	61-65	40
Guinea pig	56-75	45
Primates: Marmoset *Cynomolgus* macaque	144 153-167	96 102
Mouse	19-21	15
Rabbit	29-32	22
Rat	19-21	15

14.2. Primates

One of the main threats to good welfare regarding importing non-human primates from overseas is their prolonged transport. Even though some improvements have been made concerning the shipment containers and their equipment during the last few years, transport causes an enormous stress for the animals (Wolfensohn, 1997; Prescott, 2002). In contrast to the transport of farm animals, there has been little systematic research designed to assess the impact of transport on non-human primates (Wolfensohn, 1997) although there has been much speculation on the potential impact of this practice.

The transport procedure may start at the breeding centre some two to three weeks before shipment. The animals are separated from their groups and taken into single cages for medical investigations and quarantine. At the end of this period they are placed into transport crates that are very small. The size of these crates for smaller species is only 25x40x50 cm, and for young macaques it is 30x50x65 cm. If they are being imported from outside the EU they can spend a minimum of 36 hours in these crates but it is often more than 50 hours. This is the time it takes for the journey to the airport, to check-in and load, the flight to the European destination, to check-out with customs. After appropriate veterinary checks, the animals are transported to their final destination. During this time food and drink are restricted, they can be exposed to an extreme range of temperatures, and draughts and noise cannot always be avoided. Animals may sometimes have to wait on the runway for hours before they are loaded into the aircraft. Land journeys can also be very stressful for animals, for example, most road transport vehicles are not fully air-conditioned and the animals may be exposed to extremes of temperature and humidity.

Another factor is that some international airlines have in recent years decided to cease transporting non-human primates. Possible contributory factors to such decisions may have been safety concerns following the shipment of a consignment of primates infected with an Ebola-like virus in the early 1990s, as well as campaigning by animal rights groups. Consequently it may be more difficult to import non-human primates and this can have serious welfare implications if transport conditions are not optimised. To safeguard the welfare of non-human primates during transport, staff that are sufficiently trained or experienced in the transport of non-human primates, and with the necessary expertise and infrastructure are important considerations. IATA Guidelines (2002) can be a useful tool to advise airlines of specific considerations regarding the transport by air of non-human primates (www.iata.org).

There is some work in progress on monitoring the behavioural and biomedical sequelae of transport (see chapter 12.1) but it is clear that it must have negative effects on welfare. Diarrhoea, which is the main clinical problem during quarantine of imported primates, may be due in part to the stress of transport

15. TRANSPORT OF FISH

15.1. Introduction

There is very little published scientific information on transport or transport stress in fish. This is the case even for the rainbow trout, which is the most widely studied of the farmed species. More than 60 different species of fish are reared in aquaculture and even more are transported for the aquarium trade, as baitfish or for research purposes. There is great variation in their oxygen, pH, salinity and temperature requirement and also, more importantly in relation to transport stresses, in the range of variance they can survive. Carp and tilapias, for example can survive levels of oxygen deficit and suspended solids that would be unacceptable to salmonids while eels and freshwater catfish, which can extract oxygen from the atmosphere provided they are kept moist, can be safely transported without water. Thus each of the many species has its own requirements for safe transportation and as a consequence it is extremely difficult to generalise in defining optimal conditions around which legislation or codes of practice could be formulated.

As in mammals and birds, the stress response in fish involves the activation of 2 main neuro-endocrine systems: the sympathetico-chromaffin system producing the catecholamines (mainly adrenaline, nor-adrenaline with a very rapid secretion) and the hypothalamo-pituitary-interrenal (HPI) axis (equivalent to the hypothalamo-pituitary-adrenal cortex of mammals that produces cortisol with a slower secretion). The increased catecholamine secretion induces rapid changes in the vascular and respiratory systems, resulting in an increase in oxygen uptake. However, these respiratory and vascular adjustments impact on the osmotic balance: a net loss of plasma ions occurs in fresh water and a net increase occurs in seawater. Cortisol has an opposite effect on ion fluxes and ameliorates the osmotic disturbance. Cathecholamine stimulates glycogenolysis, and cortisol stimulates gluconeogenesis from non-carbohydrate sources.

Stressful stimuli have been shown to produce a wide variety of effects on transported fish, such as metabolic (decrease in liver glycogen levels –Paxton et al, 1984; Vijayan et al, 1990), hormonal and behavioural alterations (Montero et al, 1999). Loading and transport resulted in an elevation of circulating levels of cortisol, glucose and lactate (Specker and Schreck, 1980; Maule et al, 1988). Immunosuppressive effects of glucocorticoids as well as osmoregulatory problems result in activation of latent disease organisms and they are the major causes of death when fish are handled and transported.

Stressors have additive or synergistic effects and this has important implications for transport management and emphasises the need to avoid multiple stresses. For example, it is important to avoid a thermal shock following the transport of fish (Pickering 1992). To minimise stress, anaesthesia has been used. It is effective in promoting survival in some fish species subjected to multiple stresses or to severe transport (Strange and Schreck, 1978) Anaesthesia inhibits the stress-induced cortisol response of rainbow trout subjected to confinement (Pickering et al., 1991).

There are five main methods used to transport fish: well-boats, towing of cages by tugs, helicopter transport of open bins, insulated tanks and sealed plastic bags in insulated boxes. In well-boats, the seawater quality is maintained at a high level by continuously pumping in or recirculating seawater. Towed cages are particularly successful in the extensive Atlantic and Pacific tuna fattening industries which are developing in the Mediterranean and off Australia. The cages are large, robust and towed slowly over several weeks from the place of capture to the site for farming. Helicopters are used to move salmon smolts over short distances. The fish are densely stocked in a bucket containing highly oxygenated water carried underneath the helicopter. Tanks or plastic bags are probably still the most commonly used system for fish transportation. Tanks can be open or closed with consequent effects on water quality during transport. Usually sealed bags are used for small fish (ornamental fish, fry) or small numbers of fish.

15.2. Pretreatment before loading

Preparation for collection (towing of cages, draining of ponds…) may stress the fish due to overcrowding and poor water quality (low oxygen, high temperature). McDonald et al, (1993) have recommended various ways by which initial disturbance can be minimised when fish are loaded into transport tanks and though this is certainly an aspiration that should always accompany preparation for fish transport, there is little agreement on the validity of most of the special procedures that have been suggested based on very limited experimental data.

a) *Starvation before transport*. Fish are starved before transportation to allow the gut to clear and thus decrease the bacterial and faecal load placed on any holding and transport system. The length of starvation depends on the fish species (size of the gut) and of the water temperature. Unless they are loading into closed wells, salmon farmers do not starve fish before well boat journeys, as this is believed to stress the fish and wells are generally self cleaning. Larval fish have very limited food stores and do not survive starvation unless only for a short period.

b) Precapture anaesthesia. Such treatment was claimed to attenuate responses of chinook salmon to a second stressor (Strange and Schreck, 1978) and has also been recommended to be used with hybrid striped bass *chrysops x M.* (Tomasso et al, 1980) and small sea-bass. However, anaesthetised fish cannot be used for human consumption and the only anaesthetic licensed for fish in the EU is not approved for such use.

c) Habituation of the fish pre transportation Schreck et al. (1995) have shown that salmon handled before transport appeared to recover more rapidly than fish which had not been conditioned. This is not however considered feasible for normal transport purposes.

d) Minimising as far as practicable the duration of any pre-transport stresses and especially, the transport itself. Pickering and Pottinger (1989) have shown that the duration of the fish cortisol response is positively correlated with the duration of the stress itself. For largemouth bass, Carmichael et al. (1984) demonstrated a clear relation between the length of the haul and the severity of plasma chloride decrease during 4 days after the haul was completed. In the same study the authors showed that mortalities occurring within 4 days of the transport can be reduced by pretransport treatment (72h fasting and 10 days prophylactic disease treatment).

e) Use of heat shock protein exposure prior to transport. Recent studies in France, Scotland and Malta using exposure to heat shock protein in the water before transportation have produced significant results in terms of mortality reduction in trial transportations of salmon smolts and sea bass. The basis for the effect, which is recognised in higher animals, appears to be habituation of the tissues of the fish to create a similar effect to that of the habituation reported by Schreck et al. (1995) by prehandling of the fish. This process is however only at the trial stage and has not been conclusively proven on a commercial scale yet.

15.3. Loading

It has been shown for a number of species, that the initial loading of fish into the container is the most stressful component of transport (Miles et al., 1974; Specker and Schreck, 1980). Such stress results in alterations to both behaviour and physiological state (Mazeaud and Donaldson, 1977), which may give rise to transport mortality and also increases vulnerability to infection (Wedemeyer, 1976). In chinook salmon, plasma cortisol levels increases after loading and then decreases during the period of the transport (Maule et al, 1988). One significant factor in loading stress is the trauma associated with the method of transfer. (Barcellos et al, 2001; Jeon et al, 2000a, 2000b). Netting out and lifting within the net to place the fish in the container is the most widely used procedure but use of helical screw fish pumps and transfer in water through pipe systems can, except for the largest of brood fish, greatly reduce both skin trauma and cortisone levels associated with such transfer. (Helfrich et al., 2001) although this may vary by species since no difference was observed between dip net, conveyor and loading pump for loading cutthroat trout by Wagner and Driscoll, (1994).

The skin surface of all fishes is extremely delicate. The osmotic barrier is a layer of non-keratinized epithelium overlaying the scales, and so any process which traumatises the surface even without removing scales will cause significant loss of osmotic control as well as creating an opportunity for pathogen invasion. This is minimised by transferring fish the water medium. This may be achieved by means of pipes and gravity, by lifting in buckets as in helicopter transfer or by use of fish pumps. Where use of nets is unavoidable, soft, uncoated, knotless nets must be used to limit damage due to surface layer trauma (Carmichael et al, 2001). The sensitivity of fish to the different phases of transport differs greatly according to the species: initial capture and loading appear to be very stressful for salmonids rather than the transport itself (Barton et al, 1980; Specker and Schreck, 1980). Transport *per se* is stressful for carp (Svobodova et al, 1999).

15.4. Transport management

Several stressful stimuli have been identified during transport:

a) *Carbon dioxide accumulation in water*:

The use of oxygenation to support high fish densities coupled with inadequate water aeration can readily induce a carbon dioxide increase in the water to a toxic levels. Furthermore, if carbon dioxide in water is high, the carbon dioxide cannot diffuse from the blood to the water. This decreases the ability of haemoglobin to transport oxygen (the Bohr Effect), decreases the maximum oxygen binding capacity of blood (the Root effect), and increases blood acidity (hypercapnia). However, this toxic effect of CO_2 on fish is difficult to predict and the toxic concentration value decreases when the oxygen concentration in the water decreases (Westers, 2001). For salmonids, where most of the information is available, CO_2 does not usually pose a problem until levels reach 15mg/L (Bromage et al. 1992) and 20mg/l is the maximum safe recommended level for salmonids over 10g irrespective of water conditions, (for <10g. fish the maximum safe level is 10mg/L). For short term exposure CO2 is toxic at above 150mg/l.

b) *Abrupt water temperature change*:

Abrupt temperature change can also induce a cortisol response in salmonid fish (Strange et al, 1977). However, small daily cyclical change of temperature (9 to 16 C) generally has little effect. In most species, however greater daily variation will cause a chronic elevation of plasma cortisol (Thomas et al, 1986; Strange et al, 1977).

Stress induced mortality increases with increasing temperature (Strange, 1980, Barton and Schreck, 1987). This is associated with the lower water solubility of oxygen at higher temperature coupled with the higher oxygen demand of the heterothermic species as metabolic rate rises with temperature (Roberts and Rodger 2001).

c) *Water quality deterioration*:

Some excretory products, particularly ammonia, carbon dioxide and nitrite, are dangerous for fish. In water, the equilibrium between the between the ionised and unionised forms of ammonia (NH_4^+ and NH_3) depends on water pH and temperature. Increase of water pH and temperature increases non-ionised ammonia concentration (Emerson et al, 1975) which is highly toxic for fish. Carbon dioxide is also toxic for fish (see above) but high carbon dioxide concentration decreases water pH and the toxicity of ammonia. (Munro 2001) Nitrite production, due to oxidation of ammonia in the medium of the biofilter, should one be fitted, can occur during long transportations.

During transport, stress mediated increase in metabolism will lead to further accumulation of ammonia and carbon dioxide which induce further deterioration of water quality (Erikson et al., 1997). Tomasso et al. (1981a and b) have shown that oxygen depletion, and ammonia elevation can act as potent stimulators of the 2 main neuro-endocrine systems for a long period of time e.g. 24h after fish have been graded (Smart 1981). To reduce oxygen requirements normally associated with the metabolic demands of food ingestion, absorption and assimilation, food is often withdrawn 24 to 72 hours, dependent on water temperatures, prior to transport in closed systems, but not in well boats. This practice allows the guts to empty and reduces problems associated with fouling of the water with faecal material. Wherever possible fish from different groups should not be mixed in common containers during transport. This is for both biosecurity reasons, and because of severe stresses that can be induced by the disturbance of hierarchies and induction of fighting.

Reports on general effects of stress reducing techniques on improvement of transport survival are limited but the following descriptions indicate some success with use of general stress reduction strategies at least in American species. (Wedemeyer, 1972; Barton and Peter, 1982; Carmichael et al., 1984; Robertson et al., 1988).

Methods have been developed that reduce transport stress as a whole. The manipulation of the transport water osmolality, cold water transport, anaesthetic treatment prior to transport, have shown some success to reduce transport stress (Wedemeyer, 1972; Barton and Peter, 1982; Carmichael et al., 1984; Robertson et al., 1988).

15.5. Space allowance

"The maximum weight of fish that can be routinely transported in a particular fish distribution unit must usually be determined by experience because it depends on variables such as the physiological condition of the fish to be hauled, the efficiency of the aeration system, and the chemical composition of the water" (Wedemeyer, 1992). This is a statement which goes to the heart of the problem of defining specific conditions for fish transport. It is impossible to legislate for the best transport conditions without taking account of not only the species under consideration, but also water quality before loading, age size and condition of the fish, length of journey, temperature, and method of transport.

In relation to space allowance, again many factors come into play, not least of which is the type of fish. Aggressive species such as Siamese fighting fish and large male tilapias have to be transported individually, whereas salmon smolts can be safely transported in batches of many thousands. The level of consciousness of the fish is considered to be a major factor affecting both space requirement and as indicated above, the stress level of transported fish. Currently several anaesthetics such as methane tricaine sulphonate, benzocaine, metomidate and phenyl ethyl alcohol are used to sedate fish during treatment, and handling. These anaesthetics are not licensed for use for this purpose in food fish in the EU, indeed only methane tricaine sulphonate (MS222) can be used legally at all. CO_2 has also been used as an anaesthetic, but it should be proscribed on welfare grounds as its level is difficult to control, and effect is very variable due to its modification of water pH and ammonia levels. Bubbling O_2 and CO_2 can be effective if both can be kept within appropriate limits but are impractical to control over a long period. High P_{CO2} is of course lethal and there are very considerable species variations in sensitivity (Takeda, & Itazawa, 1983)

MS222 has been widely tested in the USA as a transport facilitating anaesthetic and used with success to reduce transport stress and mortality on bluegills (Webb, 1958), threadfin shad (Collins and Hulsey, 1963) and gizzard shad (Anderson, 1968). It is of concern that the use of anaesthetics and other welfare related compounds in the EU is currently greatly constrained by drug licensing arrangements which mean that compounds of generic availability or low cost are not legally available for use because of the high cost of licensing of all veterinary therapeutics relative to their potential profitability to a putative licensee.

–water temperature.

During transport, cooling the hauling tank water reduces fish metabolism (ammonia and nitrite accumulation decreases) and activity and it has been used routinely for fish transport with some success in the USA (Leitritz and Lewis, 1976; Smith, 1978 cited in Carmichael et al, 1984). It has been recommended that for every 0.5 C increases in temperature, the loading density should be decreased by 5.6% (Piper et al, 1982 in Berka, 1986). The same figures are given in Wedemeyer (1992) for salmonids (cooling hauling tank water by 1C will allow an increase in the fish loading density of about 10%). For red porgy a temperature drop from 25 to 20C reduces metabolism by about 50% and increases the carrying capacity fourfold (Takeda et al, 1989).

The rate of chilling and the lethal temperature beyond which the fish cannot survive must be determined for each species. For carp, cooling fish with water from 25 to 7C in 4 hours is claimed to increase the survival, whereas dropping fish directly into such cold water can in itself cause losses and does not reduce subsequent transport stresses. For large scale commercial fish movements involving large volumes of transport water, chilling should not be considered as an economic option.

–*Oxygen availability*.

For a given species, two factors, apart from stress, are important in terms of oxygen demand by fish during transport:

1) Water temperature (Berka, 1986). The lower the temperature is, the lower the oxygen consumption (Piper et al., 1982). In open systems, water oxygenation can be maintained by direct delivery of oxygen into the water, but it must be closely controlled, to avoid electrolyte and acid-base disturbances due to supersaturation (McDonald et al 1993). When fish are transported in a closed system, an oxygen deficit may occur when the load density is high and the transport is prolonged. For silver catfish (2g fingerlings), an oxygen deficit was observed at 20 and 25 C at the load density of 168g/l after 24 hours transportation (Golombiesky et al, 2003).

Oxygen consumption depends on the species (Berka, 1986). Cod for example can be transported at numbers as high as 540 kg/m^3 water for 48h (Staurnes 1994). It has been suggested that in calculating fish densities for transport in closed bags, the stocking density should be based on knowledge of oxygen levels measured at the end of trials (Kaiser and Vine, 1998).

2) Fish weight. Size and weight of the fish (plus temperature) has a strong effect on metabolism and oxygen consumption. Bigger fish use less oxygen than smaller fish per unit of weight.

–*length of the journey*:

In closed systems, CO_2 produced by fish can be a problem since it can reach high values (15mg/l is the highest limit for rainbow trout, see Berka 1986 for other values). If fish are transported in open tanks with good aeration, CO_2 is exchanged with air and does not increase in the water (Forsberg et al, 1999). In addition, CO_2 induces a decrease of the water pH which decreases the toxicity of ammonia accumulated during the transport. Its accumulation depends on fish metabolism (water temperature) and starvation. Therefore, in open tanks, transport time can be extended by slightly reducing pH in order to reduce ammonia toxicity (Grottum et al, 1997).

–*water change or treatment during the journey*:

Removal of excretory products such as ammonia, mucus and faeces by filtration can be used to increase the safe stocking density (Ou and Li, 1996; Takashima, 1996) and survival time (Bergero et al, 1993). Attempts have been made to reduce the effects of stress on ion balance and ameliorate the loss of homeostasis, by the use of diluted salt solutions (0.5-1.0% NaCl and in soft water $CaCl_2$ to bring hardness up to 50 mg/l) during fish transport. (Hattingh et al 1975). The beneficial effects of such treatment have been demonstrated for several species (Hattingh et al, 1975, Long et al, 1977). Buffering the water is also likely to confer benefits in situations where alkalinity is low and there is poor ventilation of the transport containers (Forsberg et al., 2001). Marked species differences exist in the efficacy of the treatments, resulting in a lack of consensus on optimal transport methods (Barton and Peter, 1982).

15.6. Recovery from transport

Recovery after transport can take several days (Bandeen and Leatherland, 1997; Carmichael, 1984) but allowing an extended time for recovery increases subsequent survival (Jonssonn et al, 1999).

Measurement of plasma cortisol levels of chinook salmon recovering from the stress of transportation suggested complete recovery after 24 hours. However other physiological data and results of challenge tests suggested that additional time may be necessary for full recovery (Maule et al, 1988). Studies with juvenile striped bass and walleye fry have shown survival to be inversely related to transport time (Pitman and Gutreuter, 1993). Tempering of recovery water with saline solution was also beneficial. Transport and post transport tempering in salts have the effect of lowering the osmotic gradient between plasma and the environment, thus reducing the energy cost of osmoregulation (Redding and Schreck, 1983).

16. Transport of other animals including exotic animals

16.1. Introduction

Exotic animals are transported for many reasons, including commercial transport for the pet market, interchange programmes between zoos, in some countries as part of circuses, and finally in reintroduction and translocation operations. The ability of exotic animals to withstand the rigours of transport is highly affected by the pre-transport handling the animals have been subjected to. This is particularly so for wild caught animals, as in addition to the stresses of capture, confinement and transport, there is the fear induced by close proximity to humans. Mortality figures can be much higher for exotic animals than those reported for many farm species, suggesting that welfare problems in connection with transport can be very severe. In addition to the direct effects of transport, an animal's immune response can be compromised post transport and lead to health problems during quarantine or after sale.

Scientific research into the effects of transport on exotic animals is sparse and with the exception of a comprehensive review by Schütz (2003) what information there is often refers to random investigations carried out by animal welfare organisations in a single country, so that the results can only give some idea of the situation. However, much general information is available on how animals cope with stressors, as well as how transport affects farm animals and this can be used to give an indication of how exotic animals may react to transport (Maas, 2000). Much information stems from codes of practice or practical experience with the transport of exotic species, e.g., CITES or IATA.

As with farm animals, a relationship has sometimes been found between the value of the animal concerned and the care that is taken during transport, so that in some studies welfare problems are often worse for species of lesser value. Wild caught animals for the pet trade are generally cheaper than captive bred animals of the same species (Vinke, 1998) and the poorest welfare and highest mortality rates are often seen for this category. Wild animals transported for translocation have a higher value and a great deal of effort is put into optimising conditions during capture, pre-transport holding, transport and post transport treatment.

Schütz (2003) showed that transport mortality was significantly higher for non-CITES species than for CITES species of mammals, birds, reptiles and amphibia and hypothesised that this could be due to greater care in handling CITES animals during transport, since public authorities pay closer attention to these species. CITES species were also more likely to be transported according to (2002) standards. This author suggested that the occurrence of shipments with a relatively high mortality showed that it should be possible to reduce mortality and mentioned factors such as too long a transport, inappropriate temperatures (mainly too cold but too hot was also mentioned), overstocking of containers, poor condition of animals before shipment, poor packaging, inadequate supply of water and food and transport of too young or pregnant animals as being some of the important factors for mortality during transport.

The transport of exotic animals can easily result in poor welfare unless carried out by professionals who have sufficient knowledge of the needs of the animals concerned and who can ensure that their needs are fulfilled (Maas, 2000; SABS 0331, 2000; Schütz, 2003). For the pet trade, it is particularly important that certain minimum standards are agreed upon regarding the pre-transport handling of wild species to be transported. At airports, animals can suffer because of slow handling, partly because customs procedures can take a long time. It is important to have the necessary infrastructure at airports, frontier posts, etc., to avoid suffering in animals.

Most exotic animals are transported in cages or crates, although there are some exceptions. AATA (2000) emphasises that in general, containers must be big enough so that the animals can stand up and lie down in their natural position, but not necessarily turn around in the container, as large specimens could damage themselves or the container if this were possible. However, some species, for example giraffes and some long-legged birds, are less at risk it they can not lie down during transport (AATA, 2000).

Not only the size of the container is important, but also it's internal design. For example, perches are important for some birds. For some species, such as primates, appropriate bedding in the form of sawdust or chippings is recommended instead of slatted flooring. Covering the container with branches and leaves can reduce stress in species that are used to natural cover (Maas, 2000, SABS 0331, 2000). On the outside of each container, information on the species, number of individuals, feeding and watering times and intervals, type of food, whether or not dangerous animals are in the container, special handling requirements, and who, when and where approved the transport, is needed.

Although there is no research on this, it is assumed that, as in farmed animals, removal from the familiar environment, loading and unloading can be very stressful to exotic animals. Therefore, if animals are to be transported by two different means, road and air transport, for example, it may be better to load them into a container at the beginning of the transport and keep them in the same container until dispatch, rather than to unload and reload them again. This is especially important for wild caught animals. In such cases containers must be adequate for both types of transport.

Thermal stress is one of the main problems during transport (ASM, 1998; Friend et al., 1994; Gaunt and Oring, 1999; McKenzie, 1993). Sufficient ventilation is necessary at all times. If suitable sites protected from adverse weather conditions are not used, higher mortalities can occur in sensitive species when containers are held stationary at airports.

Feeding and watering frequency depends on the species concerned. Water is always more important to an animal than food. For example, camelids (dromedary camel and llama) can withstand fasting periods of up to 5 days without significant changes in serum betahydroxybutyrate, although non-esterified fatty acid concentrations did rise slightly (Wensvoort et al., 2001). Small animals may have very high metabolic rates and need be fed and watered very frequently (ASM, 1998; Friend et al., 1994; Gaunt and Oring, 1999; McKenzie, 1993). Group transport may reduce stress on animals in some species, especially those living in family groups (SABS 0331, 2000). However, group transport may cause aggression, particularly when animals that are not acquainted with each other are mixed (ASM, 1998; Friend et al., 1994; Gaunt and Oring, 1999; McKenzie, 1993). The use of "piping", i.e., the placement of removable rubber or plastic pipes on horns, will reduce damage in transported wild animals (SABS 0331, 2000). Mature males and females must normally be separated from each other (AATA, 2000).

The capture of wild animals will always be a stressful event and the correct use of neuroleptics may be useful in reducing the stress and anxiety during capture, holding and transport but should not be used as a cover for sloppy and substandard procedures (Ebedes, 1992, SABS 0331 2000). A combination of neuroleptics and immobilisers is the main method used in practice to capture dangerous species such as lion, rhino, elephant, hippo, cape buffalo and giraffe in a humane way. In the following sections some information is given on the transport of various species.

16.2. Effects of transport on disease

Wild animals for the pet trade may be symptomless carriers of a number of serious diseases, some of which are zoonoses. For this reason they are often kept in quarantine before release for sale in the importing country. Any animals falling sick during the quarantine period can then be identified and the further spread of disease prevented. If, however, carrier animals concerned do not fall sick during the quarantine period (or fall sick later), there is a potential risk that they may infect susceptible animals after release, and humans, if the disease concerned is a zoonosis. Such a situation has occurred recently in the US, where the monkeypox virus has been spread to prairie dogs and humans. Human monkeypox virus is a rare disease occurring primarily in the rain forest countries of central and West Africa. Case fatality ratios in Africa have ranged from 1 to 10% (Hutin et al., (2001). In the US case, the initial spread of infection is thought to have occurred on the premises of a pet shop, where prairie dogs had been in contact with a sick Gambian giant rat (*Cricetomys emini*). The prairie dogs were sold to a number of pet owners, not all of whom were registered. The prairie dogs then became sick and spread the infection to persons having direct or close contact with them. The doomsday scenario in this case is that a sick prairie dog has been released in the wild and the monkeypox virus becomes established in the wild population. This story shows that extreme caution must be used when handling wild animals for the pet trade. Not only must animals falling sick be immediately isolated from others but persons in contact with sick animals must take hygiene precautions. All sales of wild animals must be registered, so that buyers can be traced in the event of an outbreak occurring.

16.3. General statements on current legislation

The transport of all vertebrate non-human animals within Europe is regulated by European Directive 95/29. The LABA/LASA guidelines (1993) set out general requirements for adequate care of laboratory animals in transit, although birds are not specifically mentioned. For further guidance on transporting laboratory animals, see the UFAW Handbook (Poole 1999).

Relevant US laws are the Animal Welfare Act 1970 and its 1976 amendments and the USDA provides advice on current legislation. The transport of all animals used for scientific purposes in Australia and New Zealand must comply with guidelines set out in the Australia and New Zealand Codes of Practice for the Care and Use of Animals for Scientific Purposes (AWAC 1994) and Code of Recommendations for Minimum Standards for the Welfare of Animals Transported in New Zealand (AWAC 1994, amended 1996). Other national or international regulations may apply when transporting or importing wild birds, including CITES for species that are endangered or at risk (see Section 6.1.1). These standards have been accepted by CITES and are enforceable worldwide (IATA 2002).

16.4. Birds for the pet and zoo markets

The total imports of live birds to the EU are estimated to be at least 1 million birds per year (Knights, 1990). A Dutch survey (Vinke, 1998) showed that the most popular bird species for the Dutch pet market were budgerigar, canary, Zebra finch, agapornis (love birds) and falcon parakeet. In this survey it was estimated that 33% of exotic bird species were wild caught and 67% captive bred. All budgerigars, canaries and zebra finches are captive bred and most trade with these species occurs within countries. However, some can be exposed to long transports, e.g., when new bloodstock is to be imported, and not all of these transports occur under good conditions. All small songbirds from Africa are wild caught and a popular species such as the Japanese nightingale (Asia) is mostly wild caught. Many of these species can be bred in captivity but wild caught birds are cheaper (Vinke, personal communication). Maas (2000) in a recent overview of the situation confirmed that the capture and transport of wild birds for the pet market was widespread in Africa, South America and Asia. Scientific studies on the welfare of birds for the pet trade are lacking, but mortality figures during capture, transport and quarantine are as an indicator of welfare in these animals, even though this information is not collected systematically.

16.4.1. Pre-transport treatment

Pre-transport treatment is particularly important for wild caught birds. There are serious welfare problems with catching wild birds in the field, where catching is often carried out by unprofessional people supplementing their income. Many capture related mortalities are attributable to physical injuries received during capture or from extreme fear and stress. After capture, birds are transferred to bags, baskets or small boxes or crates for transport to the trapper's home before further transport to a middleman or exporter (Jensen, 1991, Maas, 2000). The journey from the trapper's home to the exporter can take many days and transport conditions can be dusty and rough. Mortality figures as high as 50-60% have been reported for some non-CITES wild caught birds from Africa and Asia for the pre-transport period (Vinke, 1998). Maas (2000) confirmed that pre-export mortality could reach 45% in blue fronted amazons from Argentina (one third in the capture phase and two thirds in the collection phase) and was often 50% or above in birds from Senegal and Tanzania. The lower value of wild caught birds and lack of appreciation of the importance of welfare in the countries concerned exacerbates the situation.

16.4.2. Transport

In general, there are more problems before transport than during transport for wild caught birds but the treatment in the pre-transport period can seriously affect the ability of surviving birds to cope with stressors encountered during and after the transport. Thus, transport mortality can be somewhat higher for wild caught species than for captive bred species (Vinke, 1998). Maas (2000) quoted figures for birds dead on arrival (DOAs) after international transport and showed that DOAs in the various studies varied from 1 to15%. The RSPCA has estimated that for the period 1983-1989, 14.8 and 16.4%, respectively of transported Psittacines and other birds died during transport or in quarantine and MAFF mortality statistics for 1988, 1989 and 1990 (Maff 1989a; MAFF, 1990; Maff, 1991) estimated that about 2% of exotic birds were dead on arrival after international transport. Using Estrildidae as an example Jensen (1991) showed that transport mortality was 2.6% varying from 0 to 91%, depending on consignment. Using a comparative index value this author showed that transport mortality was proportional to the number of birds in a container and transport time. Although there were some confounding factors (the birds transported for the longest time were in larger groups), there was some indication that larger groups and longer journeys led to a greater mortality than smaller groups and shorter journeys. The floor space per bird and the cm perch per bird were also related to transport mortality and higher densities led to higher mortality index figures. Lindley (1995) also found that export mortality in birds was positively related to consignment size and that there was only a significant reduction in mortality when consignment sizes were drastically reduced. In this study country of origin, number of species per consignment and the quality of the post-export quarantine facilities also affected the extent of bird mortality. Schütz (2003) also indicated that mortality rate was higher for smaller bird species of lesser value that were transported in larger groups.

Vinke (1998) investigated 12 transports of bird species in and out of Amsterdam airport and found that only three (25%) could be described as careful transports (cranes and parrots from the US to the Netherlands and a grey parrot in transit from Africa to Indonesia). All of the others had deficiencies to a greater or lesser extent and it was characteristic of these that none fulfilled IATA guidelines. All transports fulfilling IATA guidelines were characterised as good. Overstocking or too small containers was common and applied to 6 of the transports (50%), and insufficient watering (or fouled water) occurred in three transports. Only one of the 12 transports in this study had dead birds on arrival (0.05% of wild caught Japanese nightingales from China transported in too small a cage). Jensen (1991) showed that conditions in the transport crates were inadequate in 37 out of 75 air shipments of birds into Copenhagen airport (49%): This comprehensive study, which included a total of 903 transport crates, showed that the main points of inadequacy were lack of ventilation (23%), no feed (14%) and no water (34%). Jensen criticised IATA for its method of calculating freight costs, as this made it cheaper for exporters to pack as many birds as possible into a crate and hope for a reasonable survival percentage, than to pay the freight of an additional crate.

On the basis of a comprehensive material of more than 6 million birds, Schütz (2003) showed that the average transport mortality of birds transported by air was 1.36% but that this varied between species and five families (*alcedinidae, nectariniidae, aegithaldidae, trochilidae and jacanidae*) had mean mortality rates above 5%. The author found that typically high average mortality rates were due to certain transports with very high mortality (up to 100%) and showed that 0.4% of transports had mortality rates greater than 50%. Only 64% of bird transports had zero mortality. Transport mortality in CITES species was also significantly lower than in non-CITES species (0.90 v. 2.25%) and none of the 28 non-CITES species investigated had a mortality of zero. Even in species with a mortality < 1% there were repeated cases of shipments > 15% dead individuals on arrival. The same author showed that average transport mortality was halved, if shipments complied with IATA standards (2002).

16.4.3. Cage sizes and design

The 29th edition of IATA's Live Animal Regulations (2002) give figures for cage sizes and design for birds of different species. Joslin and Collins (1999) suggested that perching birds should be able to perch with their heads upright and their tails clear off the floor and that the perches be of a suitable material that gives a comfortable firm grip. The IATA Live Animal Regulations and CITES drawings also emphasise this but note that: "cage dimensions should not give room for attempted flight, perches must be placed, so that droppings will not contaminate birds on lower perches or any food and water, and cage design must ensure adequate ventilation". Larger birds such as flamingos and cranes will naturally require a container with much greater dimensions particularly height. Long legged birds need to travel standing up and it is important that they can stretch fully in all directions. The use of branches and leaves as a visual screen and cover for birds at holding premises in Tanzania lowered mortality in wild birds during holding at a middleman, showing that biologically relevant enrichment could have a positive effect on bird welfare (Steinmetz et al., 1998).

Regarding access to water and feed during transport, small birds need access to clean water at all times and if feeding is necessary, seed-eating species feed on the floor. Otherwise the frequency and type of feeding and watering natural to the birds should be adhered to (CITES, 1980). It's important that the systems used ensure that water and feed are not contaminated by droppings.

Practical experience has shown that darkening containers can calm birds and the CITES (1980) guidelines note that birds should be transported in semi-darkness and, in addition, that they should be disturbed as little as possible. IATA's Live Animal Regulations also state that species that are obviously disturbed by the shipment can be calmed by reducing light and noise levels.

16.4.4. Post transport treatment

Exotic birds are generally held in quarantine before release for sale partly to ensure against zoonoses such as psittacosis and partly to prevent the spread of avian diseases. Using a sub-set of her material Schütz, 2003 showed that bird deaths in quarantine were nearly five times higher than deaths during transport (9.5 v. 2.0%). Several studies, reported in Maas (2000) showed that there is a direct relationship between DOA levels and deaths in quarantine (DIQs) with DIQs being 6-9% higher than DOAs. Maas concluded that it is reasonable to assume that a significant part of this post import mortality occurs as a result of treatment during the previous stages of the trade. Vinke (1998) also noted that even though exotic bird species survived the transport process, there could be health problems after sale suggesting that their immune response was compromised. In three case histories Jensen (1991) showed that post transport and quarantine mortality in wild caught birds varied between 39 and 63%. Some exotic species such as nectar eating hummingbirds have such special requirements as to cage design and feed, that it is doubtful whether these should be transported at all, unless their special needs can be fulfilled. The same applies to insect and fish eaters.

16.4.5. Transporting eggs

Wasting eggs is in effect wasting animals, so eggs should always be transport with extreme care is worthwhile. Embryos are particularly vulnerable to mechanical damage throughout the first two thirds of incubation and should not be transported during this period if possible. The safest time to transport eggs is before they have been incubated. If this is not possible, chicks in eggs that are pipping or close to hatching are less vulnerable than those transported during the first two thirds of incubation.

If the journey from the nest site to the establishment is short, eggs can be insulated with cotton wool or down and gently placed in a thick polystyrene box with a lid. The rate at which eggs lose heat depends on their size, but small (*e.g.* tit) eggs can be transported for up to an hour without artificial heat provided that they are well insulated. For longer journeys, a portable incubator or a small polystyrene poultry incubator that can be adapted to plug into a car cigarette lighter socket will be necessary for eggs of all species. The eggs will need to be wrapped and insulated as above and quickly placed into the incubator which should be preheated. There is no need to increase humidity within the incubator during the journey and the use of water trays or soaked cotton wool may lower the temperature so that the eggs lose heat (note that humidity control is vital after the eggs have been transferred to the fixed incubator).

A general reference on transporting a variety of birds and eggs can be found in Hawkins et al. (2001).

16.5. Reptiles, amphibians and insects for the pet and zoo markets

16.5.1. Pre-transport treatment

According to Vinke (1998), 16.000 CITES protected reptiles were imported into the Netherlands in 1996 and that 15-20% of reptiles and amphibians sold in pet shops were wild caught. The capture and pre-transport treatment of reptiles and amphibians is somewhat similar to that described for wild birds but can be more indiscriminate and is often carried out by children. According to Maas (2000), snakes are often picked up near roadsides or water, while traps and dogs are used to catch monitor lizards, all depending on size. Smaller lizards can also be ensnared using rubber bands attached to thin sticks. Evidence exists that capture can be a severe stressor in reptiles such as turtles (Magnuson et al., (1990), Gregory et al., (1996) and Cash et al., (1997). Moore et al., (1991) showed that plasma corticosterone concentrations increased six fold in wild-caught tree lizards after a ten minute handling period compared to immediately after capture. Physical restraint can lead to mortality in crocodiles and Lloyd (1999) reported that three of five unsedated Nile crocodiles (*Crocodilus niloticus)* died after capture and transport.

16.5.2. Transport

Reptiles and amphibians are cold blooded and their metabolic rates are temperature dependent and usually lower than in mammals of a comparable size. Some reptiles and amphibians can withstand temperature changes over short time spans whereas tropical species may be sensitive to low temperatures. Reducing body temperature before transport, and temperature control during transport, will reduce movement and eliminate the need for watering and feeding. IATA's Live Animal Regulations suggest that the preferred temperature range should be 15-25 C and that temperature should not fall below 7 C or be above 29 C. However, Joslin and Collins (1999) suggest that reptiles and amphibians should always be shipped under warm conditions. Large falls in temperature put the animals at risk. Maas (2000) reported an incident, where hundreds of reptiles and amphibians died in the cargo hold of an aircraft after a temperature drop from 22°C to 4°C on route from Surinam to Maastricht, the Netherlands, and Reuters (20.02.03) reported an incident, where more than 600 snakes, lizards, frogs, millipedes and insects died during a (legal) transport from Madagascar to Zurich. The mortality, which amounted to 33% of the shipment, occurred during a transfer of only 3½ hours at Charles de Gaulle airport, where the shipment was not kept warm. It was stated that the average body temperatures of survivors was 14°C when the shipment was opened and that many of the animals still alive were in poor condition.

Schütz, (2003) showed that amphibians had the highest average transport mortality of all the animal groups measured (4.96%) followed by reptilian with 3.14%. Even so, there were still differences between CITES and non-CITES species for both groups (3.40 v. 5.28 for amphibia and 1.97 v. 3.85% for reptilian). Within reptilian, lizards had a significantly higher mortality rate (4.39%) than snakes, turtles and tortoises or crocodiles, which were much lower and within the lizard family *scinicidae, lacertidae, chamaeleonidae and agamidae* all had average mortality rates above 5%. The author emphasised that mortality rates fluctuated widely, especially for amphibians, and shipments with no mortality and very high mortality were registered. She thought it likely that amphibians and reptiles, being cold-blooded animals without the ability to regulate body temperature suffer directly under adverse conditions. Unfortunately, compliance with IATA's rules was not available for shipments of amphibia and reptilian, so that it was not possible for this author to conclude that compliance would lower mortality, although this seems likely.

Smart and Bride (1993) mention overcrowding and badly packed shipments as a source of mortality in reptiles. They estimated that DOAs amounted to 2% in reptiles and that a further 2-3% die within two days of importation. Steinmetz et al. (1998) reported a DOA of 3.9% for reptiles imported to Germany in 1996, while Moritz (1995) quotes an average of 2% with a range from 0.1 to 6.4. In extreme cases Moritz mentions mortality figures as high as 84%. Vinke (1998) investigated three transit transports of reptiles and amphibians at Amsterdam airport and all of these were subjected to very long journeys (chameleons and frogs from Madagascar on route to the USA, various species, including water turtles, from Peru to Belgium and chameleons from Tanzania to Japan). Transport conditions were generally good and in this study all the animals were in good condition on inspection.

Transport will normally be in containers but the use of bags for certain species is used. Vinke (1998) also noted that chameleons were sometimes transported in individual bags and that these were in good condition on arrival. The IATA Live Animal Regulations give general guidelines for container dimensions for various reptilian and amphibian species as well as their specific requirements regarding group sizes and transport conditions in general. Reptiles and amphibians will not normally require watering or feeding during the journey, but certain species will need regular access to water during transport.

16.6. Fish for the pet market

According to a Dutch survey (Vinke, 1998), 93% of the total number of animal sold in Dutch pet shops are ornamental fish. Trade of fish species is free since most ornamental fish species are not protected. Most of them are goldfish, guppy and tretra species. Marine species are mainly caught in the wild (95% in the Dutch survey) while 100% of goldfish and 95% of other ornamental species are captive bred (Vinke, 1998).

Several problems are raised during fish trade, including capture and transport conditions to the nearest international airport, packaging, length of the journey, rearing conditions at the pet shop and at the buyers. However, data are scarce in the ornamental species to describe what are good transport conditions. It is stressed that food, social interaction between individuals, water quality, size of the bags play a role in reducing or enhancing stress of fish, but specific information on the suitable conditions for a given species are often missing.

Trauma can occur when wild species are caught because of pressure changes as fish are brought to the surface, change in feeding opportunities, change in swimming space and water quality. Mechanical and chemical methods to capture the fish (hand nets, traps, cyanide, quinaldine) may cause internal or physiological problems (Wood, 1985). Crowding and confinement have the same deleterious effect as what is known in commercial fish farming situations, including impairment of reproduction and immune system (Pickering et al, 1985). Alteration of gill and intestinal epithelia has been described upon capture and transport of carp, eel and catfish. Improper used of chemicals such as anaesthetics and antibiotics also contributes to alter fish health during transport and induce stress (Strange and Schreck, 1978).

Sandford and Banister (1991) emphasize the importance of unpacking fish carefully and under low illumination.

Poor husbandry prior to export and after arrival is thought to be responsible for diseases expressed once the fish arrive at the retailers. Noise from pumping and filtering equipment is suspected to have an impact on fish, as well as social mixing and inadequate feeding. It is emphasized that knowledge about the animals natural life style and needs are crucial.

16.7. Wild animals for translocation

The movement of wild animals takes place for a number of reasons. Previously, overpopulation was addressed by elimination and slaughter of animals from the area concerned. Today, animals are translocated and used for restocking other game parks and some (few) are transferred to zoos etc. Of course wild animals are still slaughtered for human consumption but such animals are shot in the field and hence are not transported. Capture and the subsequent treatment will always involve a degree of stress for wild animals. There is considerable scientific knowledge regarding the translocation of a wide variety of wild animals and its effect on capture myopathy and welfare, principally from South African researchers and this is described in detail in Ebedes et al., (2002a) and Ebedes et. al., (2002b), Ebedes et al., (2002c) as well as incorporated into South African guidelines for best practice (SABS 0331, 2000).

16.7.1. Pre-transport treatment

In a natural environment, an animal seldom has to run far to escape danger and it should not be assumed that an animal in good physical condition is fit. Animals will have varying degrees of parasite load that can affect their reaction to capture and certain species, e.g., kudu and giraffe, lose physical condition during winter. Catching methods must therefore reduce physical exertion as far as possible and take place at the times of year that are most appropriate for the species concerned. Animals are more physically stressed at high ambient temperatures. Most harvesting disrupts animal herds, so that it is appropriate to choose a time that will have least effect on reproduction and the separation of calves and mothers.

Capture methods for antelopes vary. One of the commonest is to use capture bomas, where animals are herded into the boma by helicopter for either direct loading into a crate or loading after a period to allow the animals to cool off before transport commences. Boma design can either be funnel shaped or include a circular section that facilitates animal forward movement and should be appropriate for the size of animal to be captured (Ebedes et al., 2002a). It is recommended that animals are tranquillised immediately after capture, as this has been found to reduce transport mortality considerably. Ebedes et al. (2002a) note that the mortality rate for springbok decreased from over 50% to 2% or less using this procedure. Based on comprehensive scientific research and practical experience, the same authors give a detailed description of the doses needed for tranquillizing the various sizes of the different species concerned. Permanent bomas, into which animals can be enticed using e.g., salt licks or water can also be used. Other methods are to chase animals into capture nets, suspended nets or under drop nets, sometimes combined with capture bomas. Net guns can be used for larger antelope to be captured in open areas.

With these methods, it is important to have sufficient people in the team, so that animals can be immediately freed from the net after administration of tranquillizer. Methods such as lasso capture, or manual capture of certain species after blinding with spotlights at night, involve physical restraint of animals and experience with farm animals has shown that restraint is a potent stressor. Well trained capture teams will reduce the risk of mishaps during the capture process, irrespective of the process used.

Chemical immobilisation using dart guns is used primarily when individual animals are to be captured from a herd or dangerous and unmanageable animals such as hippo, rhino, buffalo and elephant are to be captured. It is also used to catch aggressive and difficult animals such as gemsbok, roan and sable antelope, adult eland and kudu bulls. This method is safe provided that the darted animal is treated appropriately but is a specialised procedure needing competent staff including a wild life veterinarian who can monitor the vital signs of the immobilised animal (Ebedes et al., 2002a, SABS 0331, 2000). Ruminants must be held in sternal recumbancy with the head lifted but muzzle pointing down to prevent inhalation of regurgitated ruminal fluids and the possibility of bloat. If non-ruminant species are not kept in lateral recumbancy, breathing may be obstructed, and for rhino, it is necessary to hold the head higher than the rest of the body. Ebedes et al., (2002a) lists the doses of immobilising and tranquillising agents, as well as the antidote for the immobilising agent, for adult animals of relevant species.

Animals may be transported immediately or held in suitable facilities for collection of a load for sale at auction, for quarantine purposes or to feed emaciated individuals. Ebedes et. al., (2002b) and SABS 0331 (2000) describe the design of the facilities to be used for the various species and Ebedes and Van Rooyen (2002) other factors including feeding that are important for optimal treatment. Research has shown that some wild animals may never become accustomed to capture and proximity to humans. Cortisol levels in boma kept impala were always higher than in animals sampled in the veld and repeated sampling over a period of several months showed little adaptation to their situation (Hattingh et al. 1988). The design of holding facilities is therefore more appropriate, when wild animals have the possibility of hiding from humans.

16.7.2. Transport

Although there is no published research in this area, general rules for the transport of wild animals follow those of farm animals. Thus, Ebedes et al. 2002c state that crate materials must not damage the transported animals and the flooring must be non-slip to reduce the risk of injury. Crate ventilation is important and if tarpaulin is used to protect animals from wet weather, provisions are needed to ensure adequate ventilation. As with" other species, inspection with minimal disturbance, health checks before transport, keeping crates upright at loading and securely fixing the vehicle after loading are all important.

Wild animals can be transported individually in crates (e.g., adult male animals) or in mass crates (family and other groups). Potential problems include: animals that can be hostile to one another, animals with horns, crates not large enough for the species concerned to be able to stand up and lie down comfortably and poor loading procedures. Ebedes et al., (2002c) and SABS 0331 (2000) give specifications regarding height, length and width for individual crates for the various species, as well as stocking densities (for adult animals) and group sizes for transport in mass crates.

Ebedes et al. (2002c) state that if animals cannot turn round in crates, when transport distances are short, the risk of injury is minimised but that nevertheless on longer journeys the animals must be able to turn round in the crate. If animals are to be transported in individual crates that do not allow them to turn round, they need to be loaded so that their heads face outwards. Unfortunately, Ebedes and co-workers (2002c) do not give a definition of a short and long journey. Delays in truck departure after loading is finished can compromise the thermal environment in the crate especially if these are left standing in the sun for long periods. If animals are agitated, experience has shown that starting the vehicle engine and allowing it to idle, will calm them. The administration

of short or long acting tranquillisers seems to be necessary for some species. Ebedes et al., (2000c) give a detailed list of the agents and doses for the individual species as well as the factors that need to be taken into account for the correct application of the tranquilliser.

16.7.3. Post transport treatment

According to Ebedes et al., (2002c) there is no consensus regarding whether animals should be released into their new habitat immediately after their arrival at their destination or whether they should be kept in captivity for a period of adaptation. On the basis of practical experience, they recommend that animals should be released immediately, if they have been captured in the veld and transported immediately to their destination. If they have been transported after a period in captivity, then they should be held in captivity for a period before release. Ebedes et al., (2002c) give general guidelines for post transport treatment including ensuring that animals have access to water during the acclimatisation period. Animals still under the effects of tranquillizers must not be released if there are predators in the vicinity.

If the animals are to be released from individual crates, simultaneous opening of the doors will allow animals to move out together. Ebedes et al. (2002c) states that if animals do not immediately leave the crate, they should be given time to do so and that a non-slip ramp of maximum 30°C slope and release in an area that does not contain obstacles will reduce injury in animals. If off-loading takes place at night, animals will have difficulty in orientating themselves in their new surroundings.

16.8. Transport of Invertebrates

Invertebrates are from a number of phyla and include crustaceans such as crabs, lobsters and prawns and molluscs such as oysters, clams, mussels and cockles used for food. Some of these invertebrates are harvested from the wild, whilst some are also farmed. The transport of live crustaceans can be of long duration (often over 48 hours) and can lead to both high mortalities and reductions in flesh quality. (Goodrick et al. 1993, Taylor et al. 1997, Uglow et al. 1986). In bivalve molluscs such as mussels and oysters, where there is often a preconditioning period for depuration before transport to limit the transmission of food borne diseases, there is a well-established relationship between treatment during harvest and marketing and subsequent loss of meat quality and shelf life. Relatively little scientific study of invertebrate transport seems to have been made. We believe that there are potential welfare concerns relating to the transport of invertebrates but feel it would be inappropriate to include discussion here. This is especially because of the large differences in physiology of these animals, both in comparison with vertebrates and between the different invertebrate phyla.

16.9. Bison

Bison are very social animals and will react to danger as a group, first fleeing and then returning out of curiosity to see what the danger was. Bison cannot be handled like cattle. They are essentially wild animals, they are very strong and they are aggressive and dangerous. It is possible to habituate bison calves to routinely accept production procedures such as moving to and entering a squeeze pen using training (Lanier et al., 1999) and farmers establishing a herd are more successful if they start with calves, so that these can become used to human contact and then transfer this behaviour to animals subsequently born into the herd. Despite this, bison are still wild animals. Bison are transported for a number of reasons: translocation to other farms or between zoos and parks or for slaughter.

There are no published scientific reports on bison transport but codes of practice regarding handling systems that have been found to work in the field, either published by Grandin and co-workers on her website or in government codes, e.g. CARC (2001). All of these stress the importance of bison and human safety.

Loading (and unloading) Handling facilities are much more effective if they have solid walls of minimum 2.15m height on all fences chutes, gates and pens and fences and shutes must have toeholds and grab bars at regular intervals to provide an escape route for handlers. Handlers need to be able to operate gates without being among the bison. As bison are herd animals, they prefer to stay in groups and not be isolated. Bison do not have a strong following behaviour and if forced to go single file, will often climb over each other (Lanier and Grandin, www.grandin.com/references/bison.paper.html). Bison are therefore calmer if they are held in a group. If they must be lined up, then they must be held in separate compartments between solid sliding gates. Crowd pens leading to single file race to the transport vehicle should never be more than 1/3 full at any given time. This allows bison to maintain the dominance order and reduce conflict. Crowd pens should be circular, because as they circle around they think they are going back to where they came from (Grandin, no date). Bison tightly confined with other bison will show aggression, so that it is necessary for transport groups to consist of similar bison of the same age and gender. Loading ramps with slopes greater than 25 degrees or a step higher than 63 cm cause problems (CARC, 2001). It is best if there is a level area immediately before the truck, so that bison can walk onto and off the vehicle on a level. This is especially important on unloading, as bison do not like to come out of the truck and start downhill immediately. Bison may bolt if they are unloaded directly into a long alleyway. If there are gaps between loading ramps and the vehicle must occur or, bison will try to escape, and correct use of lighting will facilitate loading and unloading, as bison prefer to move to a lighter area from a darker.

Vehicle design. Vehicles used in practice are not designed specifically for bison but for cattle. It is important that structures are strong and that compartment doors can be fastened securely. Vehicles that can open the full width of the vehicle rather than single animal sliding doors are safer for the animals (CARC, 2001). Otherwise recommendations are as for cattle.

Stocking density and feeding watering and resting intervals. There are no scientific studies regarding optimal stocking densities for the various categories of bison or for feeding, watering and resting intervals. However, regarding the latter, CARC (2001) recommends that bison must be fed and watered within five hours of departure, if the journey is expected to take longer than 24 hours.

16.10. Circus animals

Circus animals are accustomed to the presence of humans and to regular transport, as the circus moves from site to site. Thus, transport is a way of life for circus animals (Kiley-Worthington, 1990) and they may become habituated to it. Little scientific research has been carried out in this area, so that this statement, while plausible, has not been scientifically documented. The little research that has been carried out has only used the ability of the animal to maintain normal body temperature during transport, and to a certain degree behaviour, as a measure of transport welfare. Thus, many aspects of welfare assessment have not been included in this work.

American work reported by Nevill et al., (in press) and Nevill & Friend, 2003, stated that the welfare of circus tigers was not poor during by transport provided that transport vehicle was designed optimally and the trainers or handlers were experienced. The circus tigers investigated were mainly transported singly or in small groups in their home cages which are either mounted on, or transferred to, a semi-trailer or flat bed rail car for longer transports. Transport normally occurred at night or in the early morning. Trailer surfaces were mostly insulated and ventilation was usually natural. One trailer was equipped with forced ventilation and a misting system and one had supplementary heating, but it was stated that this was mainly for the lions and not the tigers. During hot weather the animals could be hosed down before transport commenced and during cold weather extra bedding was given. Tigers are naturally adapted to a wide range of environmental conditions and this work confirmed that the body temperature of tigers was unaffected by transport under hot or cold conditions (range - 2.4 to 37.0 C). Body temperature did, however, increase by 1-2 C during the loading of cages onto the trailer, whereas it was essentially unaffected in systems with cages mounted on to a trailer.

Temperature increase was related to physical activity in the tigers at loading (pacing, roaring and swiping at crew or tractor).

The same research group (Toscano et al., 2001) investigated the transport of circus elephants during hot and cold weather and showed that when proper care is taken, the transport of circus elephants does not result in poor welfare of the animals even during extreme environmental conditions. There was no evidence of hyper -or hypothermia even during the most extreme conditions within the vehicles (range 1.9 to 37.5 C). It was, however, essential that experienced handlers are used and that transport vehicle design and conditions within transport vehicles are monitored during the transport. Circus elephants are transported in trailers or rail cars. They are walked onto the vehicle and diagonally chained during the transport from one front and one rear leg. A variety of strategies and equipment were used by circuses to maintain environmental conditions within ranges with which the elephants could cope. These could vary from insulated surfaces, forced ventilation and supplementary heating during winter transports to transporting the elephants during the cooler parts of the day in summer. Supplementary heating was especially important for juveniles

17. REFERENCES

AATA, 2000. Animal Transportation Association. Manual for the Transportation of Live Animals, 2nd ed. Redhill: Harris Associates Limited.

Alexander, T.L. 1988. Slaughter of deer. In: The Management and Health of Farmed Red Deer. (Reid H.W. Ed.), Kluwer Academic, Dordrecht, The Netherlands, 79-84.

Allwright, D.M. 1995. Ostrich diseases. In: "Practical guide for ostrich management and ostrich products." An Alltech Inc. Publication, (Sales W.A., Ed.), 20-27.

American Poultry association 1989. American Standard of Perfection. American Poultry Association, Inc., Estacada, Oregon.

Amici A. and Merendino M. 1996. Some metabolic and immunological parameters in rabbits as affected by prolonged thermal stress. 6th World Rabbit Congress, Toulose, vol. 2, 147-150.

Andersen, G. 1978. Transportskader på rein ved ulike transportmidler. Norsk Veterinærtidsskrift 90, 543-553.

Anderson, R.O. 1968. Transport of gizzard shad. Progressive Fish-Culturist 30, 184.

Anon. 1965. Table Chickens, Bulletin No. 168 MAFF, London, HMSO.

Anon., 1987. British Commercial Rabbit Association Marketing Survey. The Rabbit Farmer, 26, 10.

Anon. 1994 Code of Recommendations and minimum standards for the Welfare of Animals Transported within New Zealand, November 1994, Code No 15.

Anon. 1999. Report on transport and slaughter of production animals, Norwegian Animal Welfare Society.

Anon. 2001. Recommended Code of Practice for the care and handling of Farm Animals - Transportation. Canadian Agri-Food Research Council, Ottawa, Ontario, Canada.

Appleby, M. C., Hughes, B. O. and Arnold Elson, H. 1992. Poultry Production Systems.- Behaviour, Management and Welfare. CAB International 1992, Wallingford, Oxon OX 10 8DE, UK.

Arad, Z., Gavrieli-Levin, I., Eylath, U. and Marder, J. 1987 Effect of dehydration on cutaneous water evaporation in heat-exposed pigeons (*Columba livia*). Physiological Zoology 60, 623-630.

Ashash, E., Malkinson, M., Meir, R., Perl, S., and Weisman, Y. 1996. Causes of losses including a Borna disease paralytic syndrome affecting young ostriches of one breeding organisation over a five year period (1989-1993). Avian Diseases, 40, 240-245.

Ashby, B.H., Ota, H., Bailey, W.A., Whitehead, J.A. and Kindya W.G., (1980). Heat and weight loss of rabbits during simulated air transport. Transaction of the ASAE, 23, 162-164.

ASM, (1998). American Society of Mammalogists. Guidelines for the capture, handling and care of mammals as approved by the American Society of Mammalogists. J. Mammal. 79: 1416-1431.

Babji, A. S., Froning, G. W. and Ngonka, D. A. (1982). The Effect of Preslaughter Environmental Temperature in the Presence of Electrolyte Treatment on Turkey Meat Quality. Poultry Science 61: 2385-2389.

Baker, C.J., Dalley, S., Yang, X., Kettlewell, P.J. and Hoxey, R. (1996). An investigation of the aerodynamic and ventilation characteristics of poultry transport vehicles: Part 2, Wind tunnel experiments. *Journal of Agricultural Engineering Research* **65**: 97-113.

Baldock, N. M. and Sibly, R. M. (1990). Effects of handling and transportation on the heart rate and behaviour of sheep. *Applied Animal Behaviour Science* 28: 15-39.

Bandeen, J; Leatherland, JF (1997). Aquaculture International, vol. 5, no. 5, pp.385-396.

Barbut, S. (1996) Estimates and detection of the PSE problem in young turkey breast meat. Canadian J. of Animal Sci. 455-457.

Barbut, S., McEwen, s. A. and Julian, R. J., (1990), Turkey Downgrading: Effect of Truck Cage Location and Unloading. Poultry Sci. 69: 1410-1413.

Barcellos, L; Woehl, V; Wassermann, G; Quevedo, R; Ittzes, I; Krieger, M (2001). Aquaculture Research Vol. 32, no. 2, pp. 121-123.

Baroli, D., Liuzzo, G., Branchetti, M., Mussini, P., Guidobono Cavalchini, L. (1999) Effects of feed withdrawals on slaughter weight and processing yield of turkeys. Proceedings of the A.S.P.A. XIII Congress, Piacenza, June 21-24, 1999.

Barton, BA, & Schreck, C.B. (1987) Influence of acclimation temperature on interrenal and carbohydrate stress responses in juvenile chinook salmon (Oncorhynchus tshawytscha). Aquaculture 62, 299-310.

Barton, BA, Peter, RE (1982). Plasma cortisol stress response in fingerling rainbow trout, *Salmo gairdneri* Richardson, to various transport conditions, anaesthesia and cold shock. J.Fish Biol. 20, 39-51.

Barton, BA, Peter, RE, Paulencu, CR (1980). Plasma cortisol levels of fingerling rainbow trout (*Salmo gairdneri*) at rest, and subjected to handling, confinement, transport and stocking. Canadian Journal of Fisheries and Aquatic Science 37, 805-811.

Bartos L., (1985). Social activity and the antler cycle in red deer stags. Royal Society of the New Zealand Bullettin, 22: 269-272.

Basson P.A., and Hofmeyer J.M., (1973). Mortalities associated with wildlife capture operations. In: "The Capture and Care of Wild Animals". (Young E., Ed.), Human and Rosseau, Cape Town and Pretoria, 151-160.

Bastock M., Morris D. and Moynihan M. (1953). Some comments on conflict and thwarting in animals *Behaviour* 6: 66-83.

Bate-Smith H., and Bendall J.R., (1949). Factors determining the time course of rigor mortis. Journal of Physiology, 110: 47-65.

Batty J., (1994). Ostrich Farming. Beech Publishing House, UK.

Bayliss, P.A. and Hinton, M.H. (1990). Transportation of poultry with special reference to mortality rates. Applied Animal Behaviour Science, 28: 93-118.

Beaver B V 1992 Feline Behavior: A Guide for Veterinarians. Philadelphia: W B Saunders Company.

Beaver B V 1999 Canine Behaviour: A Guide for Veterinarians. Philadelphia: W B Saunders Company.

Becker, W. A., Worden, S. and Mirosh, L. W. (1985) Body and abdominal fat weight reduction upon feed withdrawal in Coturnix quail. Poultry Science 64: 597-599.

Berendsen K.D., (1995). Behaviour. In: "Ostrich Farm Management. (Kreibich A., and Sommer M., Eds.), Landwirtschafts, Milnster-Hiltrup.

Bergero, D; Boccignone, M; Di Natale, F; Forneris, G; Palmegiano, GB; Passaglia, E (1993). Rivista italiana di acquacoltura. Verona vol.28, no. 4, pp. 147-153.

Berka, R. (1986). Le transport des poissons vivants : étude de synthèse. EIFAC TECH. PAP no. 48, FAO, ROME (ITALY).

Berry, P. S., Kettlewell, P. J. , and Moran, P. (1990) The AFRC MarkI experimental broiler harvester Journal of Agricultural Engineering Research. 47: 153-163.

Berthelsen H. and Hansen L.T., (1999). The effect of hay on the behaviour of caged rabbits (*Oryctolagus cuniculus*). Animal Welfare, 8: 149-157.

Bertram B.C.R., (1980). Vigilance and group sizes in ostriches. Animal Behaviour, 28: 278-286.

Bertram B.C.R., (1992). The ostrich communal nesting system. Princeton University Press, Princeton, New Jersey.

Bessei W., Rivatelli D., and Reiter K., (1997). Experiments on the temperature preference in rabbits. Abstract of 11th Symposium of CELLE on housing and diseases of rabbits, fur bearing and pet animals. 121.

Bigler L., and Oester H., (1996). Group housing for male rabbits. 6th World Rabbit Congress, Toulose, 2: 411-415.

Bigot, K. Tesseraud, S. Taouis, M. & Picard, M. (2001). Posthatch feeding and early development in broiler chicks. Productions Animales, 14 (4): 219-230.

Birchard, G.F. (2000) The effect of changing the gaseous diffusion coefficient on the mass loss pattern of Hyalaphora cecropia pupae. Physiological and Biochemical Zoology 73: 488-493.

Bonsembiante M., Chiericato G.M., and Bailoni L., (1989). Risultati sperimentali sull'impiego di bicarbonato di sodio in diete per conigli da carne allevati in condizioni di stress termico. Rivista di Coniglicoltura, 9: 63-70.

Borchelt P L and Voith V L 1982 Diagnosis and treatment of aggression problems in cats Veterinary Clinics of North America (Small Animal Practice) 12: 665-669.

Bradshaw, R. H., Hall, S. J. G., and Broom, D. M. (1996a). Behavioural and cortisol responses of pigs and sheep during transport. *Veterinary Record* 138: 233-234.

Bradshaw, R.H., Kirkden, R.D. and Broom, D.M. (2002) A review of the aetiology and pathology of leg weakness in broilers in relation to welfare. Avian and Poultry Biology Reviews 13, 45-103.

Bradshaw, R.H., Parrott, R.F., Forling, M.L., Good, J.A., Lloyd, D.M. Rodway, R.G. and Broom, D.M. (1996b). Stress and travel sickness in pig: Effects of road transport on plasma concentrations of cortisol, beta endorphin, lysine and vasopressin. Journal of Animal Science, 63:507-519.

Bradshaw, R.H., Parrott, R.F., Goode, J.A., Lloyd, D.M., Rodway, R.G. and Broom, D.M. (1996c). Behavioural and hormonal responses of pigs during transport: effect of mixing and duration of journey. *Animal Science*, 62, 547-554.

Brelurut A., (1991). Effets de la capture et du transport sur quelques constantes sanguines du jeune cerf (*Cervus elaphus*), Gibier Faune Sauvage, 8 (September): 271-281.

Brocker, R, 1977. Humane transport of poultry. Du und das Tier.. 7: 1, 31-32.

Brogden, K.A., Lehmkuhl, H.D. & Cutlip, R.C. (1998). *Pasteurella haemolytica* complicated respiratory infections in sheep and goats. *Veterinary Research* 233-254.

Bromage NR, Shepherd, CJ & Roberts J., (1992). Farming systems and husbandry practice in Intensive Fish Farming, Ed CJ Shepherd & NR Bromage, pp87-92. Blackwell Science. Oxford.

Broom D.M (1986). Indicators of poor welfare. Br. Vet. J., 142, 524-526.

Broom, D.M. (1995). Quantifying pigs' welfare during transport using physiological measures. *Meat Focus International,* 4, 457-460.

Broom, D.M. (1996). Stress and travel sickness in pigs: effects of road transport on plasma concentrations of cortisol, beta-endorphin and lysine vasopressin. *Animal Science,* 63, 507-516.

Broom, D.M. (1998). Welfare, stress and the evolution of feelings. *Advances in the Study Behaviour*, 27, 371-403.

Broom, D.M. (2000). Welfare assessment and problem areas during handling and transport. In *Livestock Handling and Transport,* 2nd ed., Ed. T. Grandin, 43-61. Wallingford: C.A.B.I.

Broom, D.M. and Johnson, K.G. (1993). *Stress and Animal Welfare* Dordrecht: Kluwer.

Broom, D.M. and Kirkden, R.D. (2003). Welfare, stress, behaviour and pathophysiology. In *Veterinary Pathophysiology,* ed. R.H. Dunlop. Ames : Iowa State University Press.

Broom, D.M. and Knowles, T.G. (1989). The assessment of welfare during the handling and transport of spent hens. In *Proceedings 3rd European Symposium Poultry Welfare.* ed. J.M. Faure and A.D. Mills, 79-91. Tours : World Poultry Science Association.

Broom, D.M., Goode, J.A., Hall, S.J.G., Lloyd, D.M. and Parrott, R.F. (1996). Hormonal and physiological effects of a 15 hour road journey in sheep: comparison with the responses to loading, handling and penning in the absence of transport. *British Veterinary Journal*, 152, 593-604.

Broom, D.M., Knight, P.G. and Stansfield, S.C. (1986). Hen behaviour and hypothalamic-pituitary-adrenal response to handling and transport. *Applied Animal Behaviour Science* 16, 98.

Bubenik G.A., (1982). Chemical immobilisation of captive white-tailed deer and the use of automatic blood samplers. In: "Chemical Immobilisation of North American Wildlife" (Nielsen L., Haigh J.C., and Fowler M.E., Eds.), Milwaukee, Wisconsin: Wisconsin Humane Society, 335-354.

Bubenik G.A., e Bartos L., (1993). Cortisol levels in red deer (*Cervus elaphus*) and fallow deer (*Dama dama*) after an acute ACTH administration. Canadian Journal of Zoology, 71; 2258-2261.

Bubier, N.E., Lambert, M.S., Deeming, D.C., Ayres, L.L. and Sibly, R.M., (1996). Time budget and colour preferences (with specific reference to feeding) of ostrich (*Struthio camelus*) chicks in captivity. British Poultry Science, 37: 547-551.

Buss, E. G. (1989) Genetics of turkeys: Origin and development. World´s Poultry Sci. J. Vol. 45: 27-52.

Cadman W.A., (1966). The fallow deer. Forestry Commission Leaflet no. 52. HMSO, London, UK.

Calder, W.A., and King, J.R. (1974). Thermal and caloric relations of birds. In: "Avian Biology." vol. IV, (Farner D.S., and King J.R,. Eds.), Academic Press, New York and London, 259-414.

Canali C., Diverio S., Barone A., Dal Bosco A., and Beghelli V., (2000). The effect of transport and slaughter on rabbits reared in two different production systems. 7° World Rabbit Congress, July 4-7th, Valencia (Spain), 511-517.

CARC, (1996). Canadian Agri-Food Research Council. Recommended code of practice for the care and handling of farm animals. Farmed Deer (Cervidae). http://www.carc-crac.ca/english/codes_of_practice/dere.htm

CARC, (2001). Canadian Agri-Food Research Council. Recommended code of practice for the care and handling of farm animals: Bison.

Carlisle. A.J., Mitchell, M., Hunter, R. R., Kettlewell, P.J., & Matheau, C. (2003) Weight loss in transit: An important issue in broiler transportation. Poultry Science, 82 101 (52).

Carmichael, G.J. (1984). Long distance truck transport of intensively reared largemouth bass. Progressive Fish-Culturist, vol. 46, 111-115.

Carmichael, G.J., Tomasso, JR, Schwedler, TE (2001) Fish transportation. P641-660 in Wedemeyer GA (editor). Fish hatchery management, second edition. American Fisheries Society, Bethesda, Maryland.

Carmichael, G.J., Tomasso, JR; Simco, BA; Davis, KB (1984). Transactions of the American Fisheries Society, vol. 113, no. 6, pp. 778-785.

Carragher J.F., Ingram J.R., and Matthews L.R., (1997). Effects of yarding and handling procedures on stress response of red deer stags (*Cervus elaphus*). Applied Animal Behaviour Science, 51: 143-158.

Carter, C.S. (2001). Is there a neurobiology of good welfare? In *Coping with Challenge: Welfare in Animals Including Humans*. Ed. D.M.Broom, 11-30. Berlin: Dahlem University Press.

Carver, D. K., Fetrow, Gerig, T., Krueger, K. K. and Barnes, H. J. (2002) Hatchery and Transportation factors associated with Early Poult Mortality in commercial Turkey Flocks. Poultry Sci. 81: 1818-1825.

Cash, W.B., Holberton, R.L. and Knight, S.S. (1997). Corticosterone secretion in response to capture and handling in free-living red-eared slider turtles. General and Comparative Endocrinology 108: 427-433.

Cashman, P.J., Nicol, C.J. and Jones, R.B. (1989). Effects of transportation of the tonic immobility fear reactions of broilers. British Poultry Science, 30: 211-221.

CE, 1964. Council of Europe. Council Directive 64/432/EEC of 26 June 1964 on animal health problems affecting intra-Community trade in bovine animals and swine. OJ L121, 29/07/1964, 1977 – 2012.

CE, 1997. Council of Europe. Council Directive 95/29/EC of 29 June 1995 (amending Directive 90/628/EEC concerning the protection of animals during transport Official Journal L 282, 15/10/1997 P. 0036 – 0036).

Chapman, B.L. and Voith, V. L., (1990). Cat aggression redirected to people: 14 cases (1981-1987) Journal of the American Veterinary Medical Association 196: 947-950.

Chapman, D., and Chapman N., (1975). Fallow deer: their history, distribution and biology. Terence Dalton Ltd, Great Britain.

Chapman, N., (1993). Distribution and biology of fallow deer. Proceedings of the First World Forum on Fallow Deer Farming (Asher G.W., Ed.), 1-11.

Cheeke P.R., Patton N.M., Lukefahr S.D., and McNitt J.I., (1987). Rabbit Production. (6th Ed.) Interstate, Danville, IL, USA.

Chiericato G.M., Boiti C., Canali C., Rizzi C., and Ravarotto L., (1995). Effects of heat stress and age on growth performance and endocrine status of male rabbits. World Rabbits Science, 3 (3): 125-131.

Chiericato G.M., Ravarotto L., and Rizzi C., (1994). Study of the metabolic profile of rabbits in relation to two different environmental temperatures. World Rabbits Science, 2 (4): 153-160.

CITES guidelines for transport and preparation for shipment of live wild animals and plants, (1980). Publication from the Secretariat of the Convention IUCN, Gland, Switzerland, A UNIPUB Edition, Park Avenue South, New York.

Clift T.R., Challacombe J., and Dyce P.E., (1985). Electric fencing for fallow deer. Royal Society of New Zealand Bullettin, 22: 363-365.

Clutton-Brock, T.H., Guinness, F.E., Albon, S.D., (1982). Red Deer: Behaviour and Ecology of Two Sexes. University of Chicago Press, Chicago. USA.

Cockram, M.S. & Mitchell, M.A., (1999) Role of research in the formulation of rules to protect the welfare of farm animals during road transportation. In *Farm Animal Welfare - Who writes the rules?* Ed. A.J.F. Russel, C.A. Morgan, C.J. Savory, M.C. Appleby & T.L.J. Lawrence, Occasional Publication No 23 by the British Society of Animal Science, 1999 pp 43-64.

Collins, JL, Hulsey, AH, (1963). Hauling mortality of threadfin shad reduced with MS-222 and salt. Progressive Fish-Culturist 25, 105-106.

Coppings R.J., Ekhator N., and Ghodrati A., (1989). Effects of antemortem treatment and transport on slaughter characteristics of fryer rabbits. Journal of Animal Science, 67: 872-880.

Coulmin J.P., Frank P., Le Loup P., and Martin S., (1982). Incidence du nombre de lapin par cage d'engraissement sur les performances zootechniques. 3èmes Journèes de la Recherche Cunicole. Communication. 8-9 December, Paris, France.

Crawford, R. D. (1984) Turkey. In: Mason, I. L. (Ed.), Evolution of domesticated animals, Longman London & New York.

Crimella C., Luzi F., and Verga M., (1991). Influenza del trasporto su alcuni parametri produttivi nel coniglio da carne. Atti del XLV Convegno S.I.S.Vet., Palermo, Italy, 1927-1931.

Crowther C., (2001). Seeking a smoother ride for ostriches and emus. Biosecurity, 32 (11): 11.

Dal Bosco A., Castellini C., and Bernardini M., (1997). Effect of transportation and stunning method on some characteristics of rabbit carcasses and meat. World Rabbit Science, 5(3): 115-119.

Dalle Zotte A., Parigi Bini R., Xiccato G. and Simionato S., (1995). Proprietà tecnologiche e sensoriali della carne di coniglio. Influenza dello stress da trasporto, del sesso e dell'età di macellazione. Rivista di Coniglicoltura, 6: 33-39.

Dalley, S., Baker, C.J., Yang, X., Kettlewell, P.J. and Hoxey, R., (1996). An investigation of the aerodynamic and ventilation characterisitics of poultry transport vehicles: Part 3, Internal flow field calculations. *Journal of Agricultural Engineering Research* 65: 115-127.

Danbury, T.C., Weeks, C.A., Chambers, J.P., Waterman-Pearson, A.E. and Kestin, S.C., (2000). Self-selection of the analgesic drug carprofen by lame broiler chickens. Veterinary Record, 146: 307-311.

DBV-SPCA, (1996). Code of Practice for the Transport and Handling of Ostriches. National Council of SPCAs, Southdale, Republic of South Africa.

De Bruijne J. J. and Koster P., (1983). Glycogenolysis in the fasting dog Comparative Biochemistry and Physiology B 75: 553-555.

De Groot, J., Ruis, M.A., Scholten, J.W., Koolhaas, J.M., Boersma, W.J., (2001). Ong term effects of social stress on antiviral immunity in pigs. Physiol. Behav. 73,145-58.

Dean, W.R.J., Milton, S.J., Siegfreid, W.R., and Jarvis, M.J.F., (1994). Diet, mobility and reproductive potential of ostriches: successful tactics for life in arid regions. Wildlife Ranching: A celebration of diversity. Promedia, Pretoria, South Africa, (van Hoven W., Ebedes H., and Conroy A., Eds.), 8-16.

Decuypere, E., Tona, K., Bruggeman, V. & Bamelis, F. (2001) The day-old chick: a crucial hinge between breeders and broilers. World's Poultry Science Journal, 57: 127-138.

Deeming D.C., and Bubier N.E., (1999). Behaviour in natural and captive environments. In: "The Ostrich: Biology, Production and Health. (Deeming D.C., Ed.), CAB International, UK, (pp. 83-104).

Deeming D.C., and Dick A.C.K., (1995). Ingestion of metal objects by ostriches (*Struthio camelus*). The Veterinary Record, 137: 99-100.

Deeming, D.C., (1998). Effect of winter climatic conditions on the behaviour of adult ostriches (*Struthio camelus*) on a British farm. *Animal Welfare*, 7 (3): 307-315.

Degen A.A., Kam M., and Rosenstrauch A., (1989). Time-activity budget of ostriches (*Struthio camelus*) offered concentrate feed and maintained in outdoor pens. Applied Animal Behaviour Science, 22:347-358.

Dick, A.C.K., and Deeming, D.C., (1996). Veterinary problems encountered on ostrich farms in Great Britain. In: "Improving our understanding of ratites in a farming environment.", Proceedings of an International Conference, University of Manchester, UK 27-29th. March 1996, Deeming D.C., Ed.), 40-41.

Diverio S., Canali C., Barone A., Federici C., Pelliccia C., and Parillo F., (2003). Capture stress in ostriches: a comparison between two methods. UFAW Symposium, 2–4 April, Edinburgh, UK.

Diverio S, Federici C., Pelliccia C., Vegni F., and Beghelli V., (1998a). Slaughtering Stress in Fallow Deer (*Dama Dama*): Effect of Transport Time. 4th International Deer Biology Congress, 30 June - 4 July, Kaposvar, Ungheria, 325-326.

Diverio S., Federici C., Pelliccia C., Vegni F., Beghelli V. and Angelucci G., (1998b). Stress Response In Fallow Deer (*Dama Dama*): Effect of Preslaughter Management. 4th International Deer Biology Congress, 30 June - 4 July, Kaposvar, Ungheria, 319-321.

Diverio S., Mattiello S., Viliani M., and Beghelli V., (1997). L'allevamento di ungulati selvatici: quali strategie per il futuro? XIV Convegno Nazionale "Gruppo di Studio per Allevamenti di Selvaggina", 4-5 Aprile, Bastia Umbra (PG), 73-88.

Diverio S., Morgante M., Pelliccia C., and Lucaroni A., (1998c). Stress Responses to Different Restraining Procedures in Farmed Fallow Deer (*Dama Dama*). 4th International Deer Biology Congress, 30 June - 4 July, Kaposvar, Ungheria, 322-324.

Diverio S., Vegni F., Morgante M., and Beghelli V., (1996b). Stress ed alterazioni dell'equilibrio idro-elettrolitico in daini (*Dama dama*) sottoposti a macellazione. IV Congress de la Federaciòn Mediterranea de Sanitad y Produccion de Rumiantes (Fe. Me. S.P. Rum.), 28-29-30 Marzo, Murcia, Leon, Spagna: 241-246.

Diverio, S., Goddard, P.J., Gordon, I.J. and Elston, D.A., (1993). The effect of management practices on stress in farmed Reed Deer (*Cervus elaphus*) and its modulation by long-acting neuroleptics (LANS): Behavioural responses. Applied Animal Behaviour Science, 36:363-376.

Diverio, S., Goddard, P.J., Gordon, I.J., (1996a). Use of long-acting neuroleptics to reduce the stress response to management practices in red deer. Applied Animal Behaviour Science 49: 83-88.

Drawer, K (1980) Schlachten und Vermarkten von Geflügel. SVZ 6/1980: 187-189.

Drescher B., (1996). Deformation of vertebral column in breeding rabbits. Proceedings 6th World Rabbit Congress, Toulose, 2: 417-421.

Drew K.R., and Kelly R.W., (1975). Handling deer run in confined areas. Prodeedings of the New Zealand Society of Animal Production, 35: 213-218.

Duncan, I.J.H., (1989). The assessment of welfare during the handling and transport of broilers. In: Proceedings of the 3rd European Symposium on Poultry Welfare, Tours, France pp. 73-107.

Duncan, I.J.H., (1981). Animal rights, animal welfare – a scientist's assessment. *Poult. Sci.*, 60, 489-499.

Duncan,I.J.H., Slee, G.S., Kettlewell, P.J., Berry, P.S. and Carlisle, A.J., (1986). Comparison of stressfulness of harvesting broiler chickens by machine and by hand. British Poultry Science, 27, 109-114.

Dunnington, E.A., Siegel, P.B., (1984) . Thermoregulation in newly hatched chicks. Poultry Science 63, 1303-1313.

Ebedes, H. and Van Rooyen, J., (2002). Keeping and feeding wild animals in captivity. In: Game Ranch Management, Ed. J. du P Bothma, Van Scheik, Pretoria, South Africa. pp.441-454.

Ebedes, H., (1992). The use of tranquillizers in wildlife. Department of Agricultural Development, Pretoria.

Ebedes, H., Van Rooyen, J. and Du Toit, J.G. (2002a). Capturing wild animals. In: Game Ranch Management, Ed. J. du P Bothma, Van Scheik, Pretoria, South Africa. pp.382-440.

Ebedes, H., Van Rooyen, J. and Du Toit, J.G. (2002b). Bomas and holding pens. In: Game Ranch Management, Ed. J. du P Bothma, Van Scheik, Pretoria, South Africa. pp.132-146.

Ebedes, H., Van Rooyen, J. and Du Toit, J.G. (2002c). Transporting wild animals. In: Game Ranch Management, Ed. J. du P Bothma, Van Scheik, Pretoria, South Africa. pp.455-474.

Ellerbrock, S. and Knierim, U. (2002) Static space requirements of male meat turkeys. The Vet. Rec. 151: 54-57.

Emerson,K.; Russo,R.C.; Lund,R.E., Thurston,R.V., (1975). Aqueous ammonia equilibrium calculations: effects of pH and temperature. J. Fish. Res. Board Can. 32, 2379-2383.

Erikson, U; Sigholt, T; Seland, A (1997). Handling stress and water qulity during live transportation and slaughter of Atlantic salmon (*Salmo salar*). Aquaculture, vol. 149, no. 3-4, pp. 243-252.

Essen-Gustavsson, B. and Rehbinder, C., (1984). The influence of stress on substrate utilisation in skeletal muscle fibres of reindeer. (Rangifer tarandus L). Rangifer, 4:2-8.

Facchin E., Zanon F., Fioretti A., and Gallazzi D., (1996). Monitoring on rabbit meat production chain. 6th World Rabbit Congress, Toulose, 3: 67-71.

Falepau D.F. and Mulley R.C., (1998). Effect of slaughter technique and animal sex on the incidence of ecchymosis (blood splash) in fallow deer (Dama dama). Proceedings 4th International Deer Biology Congress, 30 June - 4 July, Kaposvar, Ungheria, 307-309.

FAOSTAT, (2002). http://apps.fao.org.

FAWC, (1995a). Farm Animal Welfare council. Report on the Welfare of Turkeys. January 1995. Tolworth, FAWC

FAWC, (1993). Farm Animal Welfare Council. Guidelines on the Welfare of farmed ostriches. Prepared by the UK Farm Animal Welfare Council 1993 and issued jointly by The Ministry of Agriculture, the Scottish Office Agriculture and Fisheries Department and the Welsh Office Agriculture Department 1994.

Ferrante V., Verga M., Canali E., and Mattiello S., (1992). Rabbits kept in cages and in floor pens: reactions in the open field-test. Journal of Applied Rabbit Research, 15: 700-707.

Ferrari P., Venturi L., and Rosmini R., (1989). Principali lesioni anatomoistopatologiche riscontrate all'ispezione sanitaria del coniglio. Rivista di Coniglicoltura, 4: 37-41.

Ferre I. Goddard P.J., MacDonald A.J., Littlewood C.A., and Duff E.I., (1998). Effect of method of blood sample collection on adrenal activity in farmed red deer and sheep following administration of ACTH. Animal Science, 67: 157-164.

Filion LG, Willson PJ, Bielefeldt-Ohmann H, Babiuk LA, Thomson RG., (1984). The possible role of stress in the induction of pneumonic pasteurellosis. Can J Comp Med 48, 268-274.

Finzi A., Kuzminsky G., Morera P., and Amici A., (1986). Alcuni aspetti della termotolleranza nel coniglio. Rivista di Coniglicoltura, 12: 51-55.

Fletcher T.J., (1988). The transport of deer. In: "The management and health of farmed deer". (Reid H.W., Ed.), Boston, Kluwer Academic Publication, USA.

Foggin C.M., (1992). Veterinary problems of ostriches. The Topaz Introduction to Practical Ostrich Farming. Zimbabwe, Superior Print.

Forsberg, J.A., Summerfelt,R.C., & Barton,B.A. (2001) Physiological and Behavioral Stress Responses of Walleyes Transported in Salt and Buffered-Salt Solutions. *North American Journal of Aquaculture* 63, 191-200.

Forsberg, JA; Barton, BA; Summerfelt, RC, (1999). Stress in fish. In Barry, T (ed); Barton, B (ed); MacKinlay, D (ed), pp. 31-36.

Forsell, L. (2002) Beretning fra Økonomisk Utvalg, pp. 12.

Fowler M.F., (1986). Restraint and handling of wild and domestic animals. Iowa State University Press, USA.

Fox M. W., (1978). The Dog: Its Domestication and Behavior New York: Gartland STM Press.

Fraser A.F. and Broom D.M., (1990). Farm animal behaviour and welfare. 3rd Ed., Bailliere Tindall, London UK (Reprinted 1996, CAB International).

Frasnca S., Jr and Khan M.I., (1997). Multiple intussusceptions in a juvenile rhea (*Rhea americana*) with proventriculus impaction. Avian Diseases, 41: 475-480.

Freeman, B.M., (1964). The relationship between oxygen consumption, body temperature and surface area in the hatching and young chick. British Poultry Science 6, 67-72.

Freeman, B.M., (1984). Transportation of poultry. World's Poultry Science Journal 40: 19-30.

Freeman, B.M., Kettlewell, P.J., Manning, A.C.C. and Berry, P.S., (1984). The stress of transportation for broilers. Veterinary Record, 114: 286-287.

Freeman, B.M., (1971). Body temperature and thermoregulation. In Physiology and Biochemistry of the Domestic Fowl Volume 2 Edited by D.J. Bell and B.M. Freeman, Academic Press, London and New York pp 1115-1151.

Friend, T. H., Toweill, D.E., Brownell, R.L., Nettles, V.F., Davis, D.S. and Foreyt, W.J., (1994). Guidelines for the proper care and use of wildlife in field research. In: Research and Management Techniques for Wildlife and Habitats. Ed. T.A. Bookhout, Bethesda, The Wildlife Society, pp. 96-105.

Froning, G. W., Babji, A. S. and Mather, F. B., (1978). The Effect of Preslaughter Temperature, Stress, Struggle and Anesthetization on Color and Textural Characteristics of Turkey Muscle., Poultry Science 57: 630-633.

FVE, (2001). Federation of Veterinarians of Europe, Transport of live animals, Position paper, FVE/01/043 - 18.05.01 – final.

Gates, R.S., Turner, L.W., Turner, G.M., Tuttle, J.W., (1989). Measured heat production in chicks. Proceedings of the American Society of Agricultural Engineers, Paper No. 894513.

Gaunt, A. S. & Oring, L. W., (1999). Guidelines to the use of wild birds in research, 2nd ed. The Ornithological Council.

Geverink, N.A., Bradshaw, R.H., Lambooij, E., Wiegant, V.M. and Broom, D.M., (1998). Effects of simulated lairage conditions on the physiology and behaviour of pigs. *Veterinary Record*, 143, 241-244.

Gigas, H. (1987) Puten. Verlag J. Neumann Neudamm.

Gnad, D., St-Jean, G., Homco, L.D., and Honnas, C., (1996). A review of some orthopedic diseases in ostriches, emus and rheas. Agri-practice, 17 (10): 28-32.

Gocke, A., (2000). Untersuchung über den Einsatz einer Hähnchenfangmaschine in Mastbetrieben in Norddeutschland. Diss., Tierärztliche Hochschule Hannover.

Goddard P. J., Gordon I.J., and Diverio S., (1993). Remote blood sampling of red deer. Fifth Felasa Symposium Welfare and Science, Brighton, 8-11 Giugno, U.K.; 71.

Goddard P.J. and Abeyesinghe S.M.A., (1997). The behavioural responses of farmed red deer to other farmed species within a simulated abattoir environment. Proceedings of the British Society of Animal Production, 16.

Goddard P.J., (1998). The welfare of deer. Acta Veterinaria Hungarica, 46 (3): 395-404.

Goddard P.J., and Grigor P.N., (1997). Lactate dehydrogenase quantification and isoenzyme distribution in physiological response to stress in red deer (*Cervus elaphus*). Research in Veterinary Science, 63: 119-122.

Goddard P.J., e Matthews L.R., (1994). Stress and animal welfare. Proceedings of the 3rd International Congress on the Biology of Deer, 28 August - 2 September, Edinburgh, UK, 336-346.

Goddard, P.J., Rhind, S.M., Hanlon, A.J., Hamilton, W.J., (1994). ACTH Stimulation Tests in Red Deer. New Zealand Veterinary Association, Proceedings of the Deer Branch Conference No.11: 147-155.

Golombieski,J.I., Silva,L.V.F., Baldisserotto,B., & da Silva,J.H.S. (2003) Transport of silver catfish (*Rhamdia quelen*) fingerlings at different times, load densitie, and temperatures. *Aquaculture* **216**, 95-102.

Gonzalez R.R., Kluger M.J., and Hardy J.D., (1971). Partitional calorimetry of the New Zealand White Rabbit at temperatures 5-35C. Journal of Applied Physiology, 31: 728-734.

Goodrick, G.B, Paterson, B.D. and Grauf, S., (1993). Air transport of live Kuruma prawns (Penaeus-Japonicus): Temperature control improves survival. Food Australia, 45 (8): 400-403.

Goodwin, T., (1986). Causes of turkey downgrading. Broiler Ind. 1:88-91.

Gorssen, J. and Koene, P., (1997). Behaviour and thermogenesis of racing pigeons housed under transport conditions. Animal Welfare 6: 153-168.

Gorssen, J., Schrama, J. W. and Heetkamp, M. J. W., (1993). The effect of water availability on metabolic heat production of heat exposed, group housed, unfed pigeons in relation to duration of exposure. *In*: Collins, E. and Boon, C. (eds) Livestock Environment IV pp560-569. ASAE publicatin 03-93: St. Joseph, USA.

Gorssen, J., Schrame, J. W., van der Hel, W., Noordhuizen, J. P. T. M and van der Linden, J. M., (1997). Optimal temperature levels for racing pigeons (columa livia) housed under transport conditions: the role of water availability and age. Vlaams Diergeneeskd Tijdschr 66: 81-87.

Grandin T., (2000). Handling and welfare of livestock in slaughter plants. In: Livestock Handling & Transport 2nd edition (ed. T. Grandin). CABI Publishing, Wallingford, Oxon. Chapter 20, pp 409-439.

Grandin T., (1990). Design of loading facilities and holding pens. Applied Animal Behaviour Science, 28 (1-2): 187-201.

Grandin, T., (1980). Observations of cattle behaviour applied to the design of cattle handling facilities. *Applied Animal Ethology* 6, 19-31.

Grandin, T.,(1982). Pig behaviour studies applied to slaughter plant design. *Applied Animal Ethology* 9, 141-151.

Grandin, T., (1989). Behavioural principles of livestock handling. *Professional Animal Scientist* 5 (2), 1-11.

Gregory, L.F. Gross, T.S., Bolton, A.B., Bjornedal, K.A. and Guillette, Jr., L.J., (1996). Plasma corticosterone concentrations associated with acute captivity stress in wild loggerhead sea turtles (Carretta caretta). General and Comparative Endochrinology 104: 312-320.

Gregory, N. G., Wilkins, L.J., Elepheruma, S.D., Ballantyne, A.J. and Overfield, N.D., (1990) . Broken bones in domestic fowls: effect of husbandry system and sunning method on end-of-lay hens. British Poultry Science 31, 59-69.

Gregory, N.G., (1998). Livestock presentation and welfare before slaughter. In Animal Welfare and Meat Science, N.G. Gregory (with a chapter by T. Grandin) CABI Publishing, CABI International Oxon, UK.

Gregory, N.G. and Austin, S.D., (1992). Causes of trauma in broilers arriving dead at poultry processing plants. Veterinary Record, 131: 501-503.

Gregory, N.G. and Wilkins, L.J., (1990). Broken bones in chicken. 2. Effect of stunning and processing in broilers. British Poultry Science, 31: 53-58.

Gregory, N.G. and Wilkins, L.J., (1992). Skeletal damage and bone defects during catching and processing. In: Bone Biology and Skeletal Disorders in Poultry. 23rd Poultry Science Symposium. World's Poultry Science Association, Edinburgh, UK.

Gregory, N.G. and Wilkins, L.J., (1989). Broken bones in domestic fowl: handling and processing damage in end-of-lay battery hens. *British Poultry Science* 30, 555-562.

Gregory, N.G., and Wilkins, L.J., (1989). Handling and processing damage in end-of-lay hens. British Poultry Science, 30, 555-562.

Griffiths, G.L. and Nairn, M.E., (1984). Carcass downgrading of broiler chickens. British Poultry Science, 25, 441-446.

Grigor, P.N., Hughes, B.O. and Appleby, M.C., (1995a). Effects of regular handling and exposure to an outside area on subsequent fearfulness and dispersal in domestic hens. Applied Animal Behaviour Science, 44: 47-55.

Grigor P.N., Goddard P.J., and Littlewood C.A., (1995b). The behavioural and physiological reactions of farmed deer to transport. Proc. UK Regional ISAE Meeting, London, 1-2.

Grigor P.N., Goddard P.J., Cockram M.S., Rennie, S.C., and Macdonald A.J., (1997a). The effects of some factors associated with transportation on the behavioural and physiological reactions of farmed red deer. Applied Animal Behaviour Science, 52: 179-189.

Grigor P.N., Goddard P.J., Mac Donald A.J., Brown S.N., Fawcett A.R., Deakin D.W., and Warriss P.D., (1997b). Effects of the duration of lairage following transportation on the behaviour and physiology of farmed red deer. The Veterinary Record, 4: 8-12.

Grigor, P.N., Goddard, P.J. and Littlewood, C.A., (1997c). The movement of farmed deer through raceways. Applied Animal Behaviour Science 52: 171-178.

Grigor P.N., Goddard PJ. and Littlewood C.A., (1998a). The behavioural and physiological reactions of farmed deer to transport: effects of sex, group size, space allowance and vehicular motion. Applied Animal Behaviour Science, 56: 281-295.

Grigor P.N., Goddard P.J., and Littlewood C.A., (1998b). The relative aversiveness to farmed deer of transport, physical restraint, human proximity and social isolation. Applied Animal Behaviour Science, 56: 255-262.

Grigor P.N., Goddard P.J., Littlewood C.A. and Deakin D.W., (1998c). Pre-transport loading of farmed red deer: effects of previous overnight housing environment, vehicle illumination and shape of loading race. The Veterinary Record, March 14, 265-268.

Grigor P.N., Goddard P.J., Littlewood C.A. and Macdonald A.J., (1998d). The behavioural and physiological reactions of farmed red deer to transport: effects of road type and journey time. Applied Animal Behaviour Science, 56: 263-279.

Grigor P.N., Goddard P.J., Littlewood C.A., Warriss P.D. and Brown S.N., (1999). Effects of preslaughter handling on the behaviour, blood biochemistry and carcases of farmed deer. The Veterinary Record, February 27, 223-227.

Gross, W.B. & Colmano, G., (1969). The effect of social isolation on resistance to some infectious diseases. *Poultry Science* 48: 514-520.

Gross, W.B. & Colmano, G., (1971). Effect of infectious agents on chickens selected for plasma corticosterone response to social stress. *Poultry Science* 50: 1213-1217.

Grottum, J.A., Staurnes,M., & Sigholt,T., (1997). Effect of oxygenation, aeration and pH control on water quality and survival of turbot, Scophthalmus maximus (L.), kept at high densities during transport. *Aquaculture Research* 28, 159-164.

Grzimek, B., (1969). Grzimeks Tierleben. Bd. VIII. Kindler Verlag Zürich.

Guise, J. (1991). Humane animal management – the benefits of improved systems for pig production, transport and slaughter. In: Carruthers, S.P. [ed]. *Farm Animals: It Pays to be Humane.* CAS Paper 22, Centre for Agricultural Strategy, Reading, 50-58.

Guise, J. and Penny, R.H.C., (1989). Factors affecting the welfare, carcass and meat quality of pigs. Animal Production 49, 517-521

Gunn D., and Morton D.B., (1995). Inventory of the behaviour of New Zealand White rabbits in laboratory cages. Applied Animal Behaviour Science, 45: 277-292.

Hackl, G., Kaleta, E. F., (1997). Methods for the estimation of the age of broilers and effects of water and feed deprivation within the first days of life. Arch. Geflügelk. 1997 61, 280-286.

Hafez E.S.E., (1975). The behaviour of domestic animals. (3rd Ed.) Balliere-Tindall, London, UK, 418-437.

Haigh J.C. and Hudson R.J., (1993). Farming Wapiti and Red Deer. Mosby, Toronto, 67-98.

Hall, S. J. G.; Broom, D. M and Kiddy, G. N. S., (1998a). Effect of transportation on plasma cortisol and packed cell volume in different genotypes of sheep. *Small Ruminant Research* 29: 233-237.

Hall, S. J. G.; Forsling, M. L. and Broom, D. M., (1998b). Stress responses of sheep to routine procedures: changes in plasma concentrations of vasopressin, oxytocin and cortisol. *Veterinary Record* 142: 91-93.

Hall, S.J.G., Schmidt, B. and Broom, D.M., (1997). Feeding behaviour and the intake of food and water by sheep after a period of deprivation lasting 14h. *Animal Science*, 64, 105-110.

Hallam M.G., (1992). The Topaz Introduction to Practical Ostrich Farming. Zimbabwe, Superior Print.

Hamdy MK, May KN, Powers JJ, Pratt De., 1961. Effect of ascorbate on healing of poultry bruises. Proc Soc Exp Biol Med. 108,189-92.

Hamsic, H., Redmann, T.., Annemüller, C., Beck, I., Bönner, B., Bolte, A. L., Heffels-Redmann, U., Jäger, S. Reichel, U., Schütz, S., Voelckel, K. und Kaleta E. F., (2003). Estimation of the age and rates of survival of female and male turkey poults within the first week of life using non-invasive morphometriic mehods with reference to variing times of food and water deprivation. Archiv für Geflügelkunde 1/2003: 28-37.

Hanlon A.J., Rhind S.M., Reid H.W., Burrells C., and Lawrence A.B., (1995). Effects of repeated changes in group composition on immune response, behaviour, adrenal activity and liveweight gain in farmed red deer yearlings. Applied Animal Behaviour Science, 44: 57-64.

Hanlon A.J., Rhind S.M., Reid H.W., Burrells C., and Lawrence A.B., Milne J.A., and McMillen S.R., (1994). Relationship between immune response, liveweight gain, behaviour and adrenal function in red deer (*Cervus elaphus*) calves derived from wild and farmed stock, maintained at two housing densities. Applied Animal Behaviour Science, 41: 243-255.

Hannah H. W., (1998). Pets by air Journal of the American Veterinary Medical Association 213: 1263-1264.

Hansen L.T., and Berthelsen H., (2000). The effect of environmental enrichment on the behaviour of caged rabbits (*Oryctolagus cuniculus*). Applied Animal Behaviour Science, 68: 163-178.

Harcourt R., (1995). Temperature rising. The Deer Farmer, September, 41-42.

Hargreaves A.L., and Matthews L.R., (1995). The effect of water deprivation and subsequent access to water on plasma electrolytes, haematocrit and behaviour in red deer. Livestock Production Science, 42: 73-79.

Harkness J.E., (1988). Rabbit behaviour as related to environmental stress. Journal of Applied Rabbit Research, 11(3): 227-236.

Harris T.C., (1996). AATA Manual for the Transportation of Live Animals by Road - 1st Edition, 75-76.

Harthoorn A.M., (1982). Mechanical capture as a preliminary to chemical immobilization and the use of taming and training to prevent post-capture stress. In: "Chemical Immobilization of North American Wildlife" (Nielsen L., Haigh J.C., e Fowler M.E., Eds.), Wisconsin Humane Society, Milwaukee, Wisconsin, USA, 150-164.

Hastein T., (2003). Role and Function of the OIE Fish Diseases Commission . In International Response to Infectious Salmon Anaemia. Proceedings of Symposium . USDA Technical Bulletin 1902; US Dept Of Agriculture, Washington.. pp 13-23.

Hattingh, J, Fourie, F, Van Vuren, J., (1975). The transport of freshwater fish. Journal of Fish Biology 7, 447-449.

Hattingh, J., Pitts, N.I. and Ganhao, M.F. (1988). Immediate response to repeated capture and handling of wild impala. J Experimental Zoology 248: 109-112.

Hawkins, P. Morton DB *et al*,, (2001). Laboratory birds: refinements in husbandry and procedures. 5th Report of the BVAAWF/FRAME/RSPCA/UFAW Joint Working Group on Refinement. Laboratory Animals 35: Supplement 1

Hediger, H., (1964). Wild Animals in Captivity. Dover Publications, Inc., New York. USA.

Held S.D.E., Turner R.J., and Wootton R.J., (1993). Social behaviour and immunological correlates in group-housed female laboratory rabbits. Proceedings of the International Congress on Applied Ethology, KTBL, Damstadt, Berlin, 131-135.

Held S.D.E., Turner R.J., and Wootton R.J., (1994). Effect of environmental enrichment on the behaviour of group-houses New Zealand White and Dutch X Californian laboratory rabbits. Proceeding of the Fifth FELASA Symposium, RSM Press, London, 359-360.

Held S.D.E., Turner R.J., and Wootton R.J., (1995). Choices of laboratory rabbits for individual or group-housing. Applied Animal Behaviour Science, 46: 81-91.

Helfrich, LA; Liston, C; Weigmann, D (2001). Aquaculture 2001, Lake Buena Vista, FL (USA), 21-25 Jan 2001.

Hemsworth, P.H. and Coleman, G.J., (1998). *Human-livestock interactions: the stockperson and the productivity and welfare of intensively farmed animals*. Wallingford: C.A.B.I.

Henken, A.M., van der Hel, W., Hanssen, E.J.M., Scheele, C.W., van Kampen, M. (1989) The effect of dry and wet bulb temperature on heat production of newly hatched chicks. In Energy Metabolism of Farm Animals. Wageningen, Netherlands. pp 291-294.

Hertrampf, J., (1987). quails in Asia. Pultry International 26(5): 114-122.

Higgs, A.R.B., Norris, R.T. & Richards, R.B., (1993). Epidemiology of salmonellosis in the live sheep export industry. *Australian Veterinary Journal* 70: 330-335.

Horalek G. and Jones A.R., (1993). The heart rate of farmed deer during and after transportation. Applied Animal Behaviour Science, 38 (1): 76.

Houpt K. A., (1998). Domestic Animal Behavior for Veterinarians and Animal Scientists, 3rd ed. Ames: Iowa State University Press.

Hoxey, R. P., Kettlewell, P. J., Meehan, A. M., Baker, C. J. and Yang, X., (1996). An investigation of the aerodynamic and ventilation characteristics of poultry transport vehicles: part I, full scale measurements. Journal of Agricultural Engineering Research 65, 77-83.

Hughes B.O., and Duncan I.J.H., (1988). The notion of ethological "need", models of motivation and animal welfare. Animal Behaviour, 36: 1696-1707.

Hulot F. and Ouhayoun J., (1999). Muscular pH and related traits in rabbits: a review. World Rabbit Science, 7 (1): 15-36.

Huls W.L., Brooks D.L., and Bean-Knudsen D., (1991). Response of adult New Zealand White Rabbits to enrichment objects and paired housing. Laboratory Animal Science, 41 (6) 609-612.

Hunter, R. R., Mitchell, M. A. and Matheu, C., (1997). Distribution of 'dead on arrivals' within the bio-load on commercial broiler transporters: correlation with climate conditions and ventilation regimen. British Poultry Science 38: Supplement, S7-S9.

Hunter, R. R., Mitchell, M.A. & Matheu, C., (2001). Mortality of broiler chickens in transit - correlation with the thermal micro-environment in: Proceedings of the 6th International Livestock Environment Symposium, Louisville, Kentucky, U.S.A., 21st-23rd May 2001. Edited by Stowell, R. R., Bucklin, R. & Bottcher, R. W. pp 542-549.

Hunter, R.R., Mitchell, M.A., Carlisle, A.J., Quinn, A.D., Kettlewell, P.jJ, Knowles, T.G. and Warriss, P.D., (1998). Physiological responses of broilers to pre-slaughter lairage: effects of the thermal micro-environment? British Poultry Science, 39: S53-S54.

Hurni H. and Rossbach W., (1987). The laboratory cat IN: Poole T B (ed) The UFAW handbook on the care and management of laboratory animals Harlow: Longman Scientific and Technical, pp.476-492.

Hutin, Y.J.F., Williams, R. J., Malfait, P., Pebody, R., Loparev, V.N., Ropp, S.L., Rodriguez, M., Knight, J.C., Tshioko, F.K., Khan, A.S., Szczeniowski, M.V. and Esposito J.J. (2001). Outbreak of Human Monkeypox, Democratic Republic of Congo, 1996–1997, Emerging Infectious Diseases 7: 434-438.

IATA, (2002). International Air Transport Association. Live Animal Regulations Montreal.

Ingram J.R., Matthews L.R., and MaDonald R.M., (1994). Remote blood sampling device. A stress free blood sampling technique for free ranging animals. Proc. New Zealand Society of animal Production, 54: 39-42.

Ingram J.R., Matthews L.R., Carragher J.F. and Schaare P.R., (1997). Plasma cortisol responses to remote adrenocorticotrophic hormone (ACTH) infusion in free-ranging red deer (*Cervus elaphus*). Domestic Animal Endocrinology, 14: 63-71.

Itoh, T., Kobayashi, S., Sugawara, H. and Adachi, S., (1981). Some physico-chemical changes in quail egg white during storage. Poultry Science 60: 1245-1249

Jacobsen N.R., (1979). Changes in heart rate with growth and activity of white-tailed deer fawns (*Odocoileus virginianus*). Comparative Biochemistry and Physiology, 62 A: 885-888.

Jago J.G. and Matthews L.R., (1998). The effect of transport on carcass quality and welfare of red deer (*Cervus Elaphus*). Proceedings of the 3rd International Congress on the Biology of Deer, 28 August - 2 September, Edinburgh, UK, 379.

Jago J.G., Harcourt R.G., and Matthews L.R., (1997). The effect of road-type and distance transported on behaviour, physiology and carcass quality of farmed red deer (*Cervus elaphus*). Applied Animal Behaviour Science, 51: 129-141.

Jago J.G., Hargreaves A.L., Harcourt R.G. and Matthews L.R., (1996). Risk factors associated with bruising in red deer at a commercial slaughter plant. Meat Science, 44 (3): 181-191.

Jago J.G., Matthews L.R., Hargreaves A.L., and van Eeken F., (1993). Pre-slaughter handling of red deer: implications for welfare and carcass quality. Proceedings of a Deer Course for Veterinarians, 10: 27-39.

Jensen, M. (1991). The importance of transport conditions for the mortality in tropical birds imported by air. PhD thesis, University of Copenhagen, Denmark.

Jensen, P. (1994). Fighting between unacquainted pigs: effects of age and of individual reaction pattern. *Applied. Animal Behaviour Science,* 41, 37.

Jensen, P. and Toates, F.M., (1993). Who needs behavioural needs – motivational aspects of the needs of animals. *Appl. Anim Behav. Sci.,* 37, 154-164.

Jeon, J.K., Kim, P.K., Park, Y.J., Myoung, J.G., and Kim, J.M., (2000a). Changes of serum cortisol concentration and stress responses in coho salmon (Oncorhynchus kisutch) to netting. *Journal of the Korean Fisheries Society* 33, 115-118.

Jeon,J.K., Kim,P.K., Park,Y.J., Myoung,J.G., & Kim,J.M., (2000b). Stress responses of coho salmon, Oncorhynchus kisutch, to transport in fresh water or salt water. *Journal of the Korean Fisheries Society* 33, 119-123.

Jolley P.D., (1990). Rabbit transport and its effects on meat quality. Applied Animal Behaviour Science, 28: (1-2): 119-134.

Jones, A.R. and Price, S.E. (1992). Measuring the response of fallow deer to disturbance. In: Brown, R.D. (ed.) *The Biology of Deer,* Springer Verlag, Berlin.

Jones, J. E., Hughes, B. L. and Hale, K. K. (1979) Coturnix D1 carcass yield. Poultry Science 58, 1647-1648.

Jones, R.B. (1996). Fear and adaptability in poultry: insights, implications and imperatives. World's Poultry Science Journal, 52, 131-174.

Jonssonn, S; Braennaes, E; Lundqvist, H (1999). Fisheries Management and Ecology Vol. 6, no. 6, pp. 459-473.

Jopson N.B, Fisher MW., and Suttie J.M., (1990). Plasma progesterone concentrations in cycling and ovariectomised red deer hinds: the effect of progesterone supplementation and adrenal stimulation. Animal Reproduction Science, 23: 61-73.

Joslin, J.O. and Collins, D., (1999). Designing an ideal animal shipment. In :Fowler, M.E. and Miller, R.E., Zoo and Wild Animal Medicine. Current Therapy, pp. 17-26.

Julian, R.J. (1984). Valgus-varus deformity of the intertarsal joint in broiler chickens. Canadian Veterinary Journal, 25, 254-258.

Jurkschat, M., Burmeister, A., Nichelmann, M and Thomas, E., (1986). A mathematical equation to describe the influence of age, wind speed and ambient temperature on heat production in turkeys (*Meleagris gallopavo*) J. therm. Biol. 11: 105-108.

Kaiser, H; Vine, N (1998). Aquarium Sciences and Conservation. Vol. 2, no. 1, pp. 1-7.

Kamau J.M., Patrick B.T., and Mushi E.Z., (2002). The effect of mixing and translocation juvenile ostriches (*Struthio camelus*) in Botswana on the heterophil to lymphocyte ratio. Tropical Animal Health and Production, 34: 249-256.

Kannan, G. and Mench, J.E., (1996). Influence of different handling methods and crating periods on plasma corticosterone concentrations in broilers. British Poultry Science, 37: 21-31.

Karsh E. D. and Turner D. C., (1988). The human-cat relationship IN: D C Turner and P Bateson (eds) The domestic cat: the biology of its behaviour Cambridge: Cambridge University Press pp.159-177

Kay R.B.N., Sharman G.A.M., Hamilton W.J., Goodall E.D., Pennie K., and Coutts A.G.P., (1981). Carcass characteristics of young red deer farmed on hill pasture. Journal of Agriculture Science, 96: 79-81.

Kelley, K.W., (1985). Immunological consequences of changing environmental stimuli. In: Moberg, G.P. (ed.) *Animal Stress*, American Physiological Association, 193-223.

Kemppainen, J., Kettunen, J. and Nieminen, M., (2002). Economic utilisation of reindeer. 12th Nordic conference on Reindeer Research, Kiruna, Sweden, 11-13th March.

Kenny, F.J. and Tarrant, P.V., (1987). The reaction of young bulls to short-haul road transport. *Applied Animal Behaviour Science* 17, 209-227.

Kersten A.M.P., Meijsser F.M., and Metz J.H.M., (1989). Effects of early handling on later open-field behaviour in rabbits. Applied Animal Behaviour Science, 24 : 157-167.

Kestin, S.C., Gordon, S., Su, G. and Sorensen, P. (2001). Relationships in broiler chickens between lameness, liveweight, growth rate and age. Veterinary Record, 148, 195-197.

Kestin, S.C., Knowles, T.G., Tinch, A.F. and Gregory, N.G. (1992). The prevalence of leg weakness in broiler chickens and its relationship with genotype. Veterinary Record, 131: 190-194.

Kettlewell P.J. and Mitchell M.A., (1993). The thermal environment on poultry transport vehicles. Livestock Environment IV. Proceedings of the Fourth International Symposium, Eds. E.Collins & C.Boon, p552-559, American Society of Agricultural Engineers.

Kettlewell P.J., Mitchell M.A. and Meehan A., (1993). The distribution of thermal loads within poultry transport vehicles Agricultural Engineer 48 (1): 26-30.

Kettlewell, P. J., Hampson, C. J., Green, N. R., Teer, N. J., Veale, B. M. and Mitchell, M. A. (2001a). Heat and moisture generation of livestock during transportation. In: Proceedings of the 6th International Livestock Environment Symposium, Louisville, Kentucky, U.S.A., 21st-23rd May, 2001. Edited by Stowell, R. R., Bucklin, R. & Bottcher, R. W. pp 519-526.

Kettlewell, P. J., Hoxey, R. P., Hampson, C. J., Green, N. R., Veale, B. M. and Mitchell, M. A. (2001b). Design and operation of a prototype mechanical ventilation system for livestock transport vehicles. Journal of Agricultural Engineering Research, 79: 429-439.

Kettlewell, P. J., Hoxey, R.P. and Mitchell, M. A.,(2000). Heat produced by broiler chickens in a commercial transport vehicle. Journal of Agricultural Engineering Research, 75: 315-326.

Kettlewell, P. J. and Mitchell, M. A., (2001a). Comfortable ride: Concept 2000 provides climate control during poultry transport. Resource. Engineering and Technology for a Sustainable World, 8: 13-14.

Kettlewell, P.J. and Mitchell, M.A. (2001b). Mechanical ventilation: Improving the welfare of broiler chickens in transit. Journal of the Royal Agricultural Society, 162: 175-184.

Kettlewell,P.J. and Turner,M.J.B., (1985). A review of broiler chicken catching and transport systems. Journal of Agricultural Engineering Research. 31, 93-114.

Kiessling, K-H. and Kiessling, A., (1984). Fibre composition and enzyme activities in five different muscles from the Svalbard reindeer. Comparative Biochemistry and Physiology 77A: 75-78.

Kiessling, K-H. and Rydberg, A., (1983). Fibre composition and enzyme activities in six muscles of the Swedish reindeer (Rangifer tarandus L). Rangifer, 3: 40-45.

Kiley-Worthington, M., (1990). Animals in Circuses and Zoos : Chiron's World. Little Eco-Farms Publishing, Harlow, Essex, UK. Pp. 41, 175.

Klemm, R., Reiter, K. und Pingel, H., (1995). Untersuchungen zum Federpicken bei Moschusenten. Archiv für Geflügelkunde 59: 99-102.

Knezacek, T.D., Audren, G.F., Mitchell, M.A., Kettlewell, P.J., Hunter, R.R., Classen, H.L., Stephens, S., Olkowski, A.A., Barber, E.M. and Crowe, T.G., (2000). Temperature heterogeneity and moisture accumulations in trailers transporting broilers under Canadian winter conditions. *Poultry Science* 79: Supplement 1: 31.

Knierim, U. and Gocke, A., (2003). Effect of catching broilers by hand or machine on rates of injuries and dead-on-arrivals. Animal Welfare 12, 63-73.

Knights, P., (1990). Wild birds for the pet trade, an EEC overview. A report by Environmental Investigation Agency, London.

Knowles, T. G. and Wilkins, L. J., (1998). The problem of broken bones during the handling of laying hens: A review. Poultry Sci. 77: 1798-1802.

Knowles, T.G. and Broom, D.M., (1990a). The handling and transport of broilers and spent hens. Applied Animal Behaviour Science, 28: 75-91.

Knowles, T.G. and Broom, D.M., (1990b). Limb bone strength and movement in laying hens from different housing systems. Veterinary Record, 126: 354-356.

Knowles, T.G., S.N. Brown, J.E. Edwards, *et al.* (1999a) Effect on young calves of a one-hour feeding stop during a 19- hour road journey. *Veterinary Record* 1999a;144, 687-692.

Knowles, T.G. and Warriss, (2000). Stress physiology of animals during transport In: T. Grandin (ed.) Livestock Handling and Transport, CABI International, Wallingford, Oxon UK. 385-407.

LABA and LASA, (1993). Laboratory Animal Breeders Association of Great Britain () and Laboratory Animal Science Association. Guidelines for the care of laboratory animals in transit Laboratory Animals 27: 93-107

Lambert M.S., Deeming D.C., Sibly R.M., and Ayres L.L., (1995).,The relationship between pecking behaviour and growthrate of ostrich (*Struthio camelus*) chicks in captivity. Applied Animal Behaviour Science, 46: 93-101.

Lambooij, E., Broom, D.M., von Mickwitz, G. and Schutte, A., (1999). The welfare of farm animals during transport. In *Veterinary Aspects of Meat Production, Processing and Inspection*, ed. F.J.M. Smulders, 113-128, E.C.C.A.M.S.T.

Lambooij, E., Geverink, N., Broom, D.M. and Bradshaw, R.H., (1995). Quantification of pigs' welfare by behavioural parameters. *Meat Focus International*, 4, 453-456.

Lamoreux, W.F., Hutt, F.B. (1939). Variability in body temperature in the normal chick. Poultry Science 18: 70-75.

Langhout, P.J., (2001). feeding during the first week of life. International Poultry Production 9 (1): 7-10.

Langridge M., (1992). Establishing a fallow deer farm: basic principles. In: Progressive Fallow Deer Farming: Farm Development and Management Guide. (Asher G.W., and Langridge M., Eds.), Ruakura Agricultural Centre, New Zealand, 17-28.

Lanier, J. Grandin, T., Chaffin, A. and Chaffin, T., (1999). Training American bison (Bison bison) calves. Bison World, October- December , pp. 94-99.

Laughlin, K.F., (1989) . Computerised customer care. International Hatchery Practice 4: 43-45.

Leadon D. P. and Mullins E. (1991) Relationship between kennel size and stress in greyhounds transported short distances by air Veterinary Record 129: 70-73.

Lebas F., Cordert P., Rouvier R., and de Rochambeau H., (1986). The rabbit: husbandry, health and production. Animal Production and Health Series, 21, FAO, Rome, Italy.

Lehman M., (1991). Social behaviour in young rabbits under semi natural conditions. Applied Animal Behaviour Science, 32: 269-292.

Lehmann M., (1987). Interference of a restricted environment – as found in battery cages – with normal behaviour of young fattening rabbits. In “Rabbit Production Systems including Welfare” (Auxilia T., Ed.), CEC Agriculture, ECSC-EEC-EAEC, Brussels, 257-268.

Leitritz, E. & Lewis, R.C., (1976). Trout and salmon culture (hatchery methods). *Fish.Bull.State Calif., Fish Game Comm* 1-197.Lentz, C.P. & Hart, J.S. (1960) The effect of wind and moisture on heat loss through the fur of the new-born caribou. Canadian Journal of Zoology 38 (4), 679-688.

Leoni S., Meriggi F., and Ghilarducci G., (2000). Trasporto e qualità della carne. Rivista di Coniglicoltura, 3: 40-47.

Levy A., Markowittz E., Van Creveld C. and Tagil R., (1996). Water metabolism of laying ostriches. In: "Improving and Understanding of Ratites in a Farming Environment", (Deeming D.C., Ed.), Oxfordshire, Ratite Conference, 127-129.

Lidfors L., (1997). Behavioural effects of environmental enrichment for individually caged rabbits. Applied Animal Behaviour Science, 52: 157-169.

Lindley, A. (1995). Import of birds to the UK. Further analysis of MAFF Statistics 1988-1990. RSPCA Report to CITES Animals Committee, RSPCA.

Lindsay S R 2000 Handbook of Applied Dog Behavior and Training. Volume One: Adaptation and Learning. Ames: Iowa State University Press.

Lloyd, M.L. (1999). Crocodilian anaesthesia. In: M.E. Fowler and R.E. Miller (eds.) Zoo and Wild Animal Medicine. Current Therapy 4, pp. 205-216.

Lockley R.M., 1961. Social structure and stress in the rabbit warren. Journal of Animal Ecology, 30: 385-423.

Löliger H.C., (1992). Consideration of animal protection and welfare in domestic rabbit housing and management. Journal of Applied Rabbit Research, 15: 684-691.

Löliger, H.C. and Torges, H.-G.. (1977). Tierschutzgerechter Transport beim Geflügel. Du-und-das-Tier, 7: 1, 27-30

Long, CW, McComas, JR, Monk, BH (1977). Use of salt (NaCl) water to reduce mortality of chinook smolts, *Oncorhynchus tshawytscha*, during handling and hauling. Marine Fisheries Review 39, 6-9.

Love J.A., (1994). Group housing: meeting the physical and social needs of laboratory rabbits. Laboratory Animal Science, 44: 5-11.

Luzi F., Heinzi E., Crimella C., and Verga M., (1992). Influence of transport on some production parameters in rabbits. Journal of Applied Rabbit Research, 15: 758-765.

Maas, B (March 2000) Prepared and shipped. A multidisciplinary review of the effects of capture, handling, housing and transport on morbidity and mortality. Research funded by the RSPCA.

MacArthur, J. A., (1987a). The dog IN: Poole T B (ed) The UFAW handbook on the care and management of laboratory animals Harlow: Longman Scientific and Technical, pp.456-475.

MacArthur, A. J., (1987b). thermal interactions between animal and microclimate: a comprehensive model. Journal of Theoretical Biology, 126: 203-238.

MacCaluim, J.M., Abeyesinghe, S.M., White, R.P., Wathes, C.M., (2003). A continuous-choice assessment of the domestic fowl's aversion to concurrent transport stressors Animal Welfare 12 (1): 95-107.

MacDougall D.B., Shaw B.G., Nute G.R., and Rhodes D.N., (1979). Effect of pre-slaughter handling on the quality and microbiology of farmed young red deer. Journal of Science, Food Agriculture, 30: 1160-1167.

Mackintosh C.G., (1998). Deer health and disease. Acta Veterinaria Hungarica, 46 (3): 381-394.

MacLeod, M.G., (1980). The biology of survival: The effects of day old travel in chicks. In Airfreighting of Hatching Eggs and Poultry , West of Scotland College of Agriculture 1980, pp 3-5.

Maertens L., and De Groote G., (1984). Influence of the number of fryer rabbits per cage on their performance. Journal of Applied Rabbit Research, 7: 151-155.

MAFF, (1989a). Ministry of Agriculture, Fisheries and Food, England. Importation of birds. Mortality statistics from quarantine returns year ended 1988.

MAFF, (1989b). Ministry of Agriculture, Fisheries and Food, England. Guidelines for the transport of farmed deer. Leaflet 945. Lion House, Willowburn Estate, Alnwick, Northumberland NE66 2PF, UK.

MAFF, (1990) Ministry of Agriculture, Fisheries and Food, England. Importation of birds. Mortality statistics from quarantine returns year ended 1989.

MAFF, (1991) Ministry of Agriculture, Fisheries and Food, England.Importation of birds. Mortality statistics from quarantine returns year ended 1990.

MAFF, (1997). Ministry of Agriculture, Fisheries and Food, England. Ministers plan welfare code for ostrich farm. The Veterinary Record, September 13: 258.

MAFF, (1998). Ministry of Agriculture, Fisheries and Food, England. Guidance notes for road transport of ostriches (and other ratites) - Welfare of Animals (Transport) Order 1997. Ministry of Agriculture, Fisheries and Food.

Magnuson, J.J., Bjornedal, K.A., DuPaul, W.D., Graham, G.L., Owens, D.W., Peterson, C.H., Pritchard, P.C., Richardson, J.I., Saul, G.E. and West, C.W., (1990). Decline of sea turtles: causes and prevention. National Academy Press, Washington, DC.

Malmfors, G. and Wiklund, E., (1996). Pre-slaughter handling of reindeer – effects on meat quality. Meat Science, 43: 257-264.

Marder, J., (1983). Cutaneous water evaporation. II. Survival of birds under extreme thermal stess. Comparative Biochemistry and Physiology 75A: 433-439.

Martin, B.J., (1998). The Laboratory Cat Boca Raton: CRC Press.

Masoero G., Riccioni L., Bergoglio G., and Napoletano F., (1992). Implications of fasting and transportation for the high quality rabbit meat production. Proc. 5th World Rabbit Congress, Covallis, USA, July, vol. B; Journal of Applied Rabbit Research, 15: 841-847.

Matthews L., Harcourt R.G. and Carragher J.F., (2000). Thermoregulation in deer during transport. Proc. 34th Int. Congress of ISAE, 17-20 October, Florianopolis, Brazil.

Matthews L.R., (2000). Deer handling and transport. In: “Livestock Handling and Transport”, (Temple Grandin Ed.), University Press, Cambridge, 253-272.

Matthews L.R., and Cook C.J., (1991). Deer Welfare Research – Ruakura findings. Proceedings of the New Zealand Veterinary Association Annual Conference No° 8:120-127.

Matthews L.R., Cook C.J., and Asher G.W., (1990). Behavioural and physiological responses to management practices in red deer stags. Proceedings of the New Zealand Veterinary Association Annual Conference No° 7: 74-85.

Maule, A.G., Schreck, C.B., Bradford, C..S,, Barton, B.A., (1988). Physiological effects of collecting and transporting emigrating juvenile chinook salmon past dams on the Columbia River. Trans. Am. Fish. Soc. 117, 245-261.

Maxwell, M.H. and Robertson, G.W. (1998) UK survey of broiler ascites and sudden death syndrome in 1993. British Poultry Science, 39: 203-215.

May, G.C. and Hawksworth, D. (1982) British Poultry Standards, 4th edn. London, Butterworth Scientific.

Mayes, F.J. (1980). The incidence of bruising in broiler flocks. British Poultry Science, 21: 505-509.

Mazeaud, M. M. and Donaldson, E. M., (1977). Primary and secondary effects of stress in fish: some new data with a general review. Transactions of the American Fisheries Society. 106, 3, 201-212.

McAllum H.J.F., (1985). Stress and post capture myopathy in red deer. In: “Biology of Deer Production”(Fennessy P.F., and Drew K.R., Eds). The Royal Society of New Zealand Bulletin 22, Wright and Carman Ltd, Upper Hutt, New Zealand, 65-72.

McDonald, D.G., Goldstein, M.D. and Mitton, C. (1993). Responses of hatchery-reared brook trout, lake trout and splake to transport stress. Trans. Am. Fish. Soc. 122: 1127-1138.

McEwen, S. A. and Barbut, S. (1992) Survey of turkey downgrading at slaughter: Carcass defects and associations with transport, toenail trimming, and type of bird. Poultry Sci. 71: 1107-1115.

McGeown, D., Danbury, T.C., Waterman-Pearson, A.E. and Kestin, S.C. (1999). Effect of carprofen on lameness in broiler chickens. Veterinary Record, 144, 668-671.

McKee, S. R. and Sams, A. R. (1997) The Effect of Seasonal Heat Stress on Rigor Development and the Incidence of Pale, Exudative Turkey Meat. Poultry Science 76: 1616-1620.

McKeegan D.E.F., and Deeming D.C., (1997). Effects of gender and group size on the time-activity budgets of a adult breding ostriches (*Struthio camelus*) in a farming environment. Applied Animal Behaviour Science, 51: 159-177.

McKenzie, A. (1993). The Capture and Care Manual 1993. Wildlife Decision Support Services CC and The South African Veterinary Foundation, Pretoria.

McNally L., (1977). The senses of deer. Deer, 4; 134-137.

Mech, D.L. (1970) The Wolf. The Ecology and Behavior of an Endangered Species Minneapolis: University of Minnesota Press.

Meijerhof, R. (1997) The importance of egg and chick transportation. World Poultry, 13 (11): 17-18.

Mengert, U., Fehlhaber, K. und Arwana, A.-A. (1998) Investigating stress-induced endogenous microbial contamination of Muscovy ducks in connection with feeding Zinc-bacitracin. Arch. Geflügelkunde 62,(2): 49-54.

Menon, G.K., Maderson, P.F.A., Drewes, R.C., Baptista, L.F., Price, L.F., and Elias, P.M., (1996). Ultrastructural organisation of avian stratum-corneum lipids as the basis for facultative cutaneous waterproofing. Journal of Morphology, 227: 1-13.

Metheringham, J. and Hubrecht, R. (1996). Poultry in transit - A cause for concern. British Veterinary Journal 152: 247-249.

Metz J.H.M., (1983/1984). Effects of early handling in the domestic rabbit. Applied Animal Ethology, 11: 86-87 (Abstract).

Metz J.H.M., (1987). Behavioural problems of rabbits in cages. In “Rabbit Production Systems including Welfare” (Auxilia T., Ed.), CEC Agriculture, ECSC-EEC-EAEC, Brussels, 221-230.

Miles, H.M., Loehner,S.M., Michaud D.T., & Salivar,S.L., (1974). Physiological responses of hatchery reared muskellunge (*Esox masquinongy*) to handling. *Trans.Am.Fish.Soc.* **103**, 336-342.

Mills, D.S. and Nicol, C.J., (1990). Tonic immobility in spent hens after catching and transport. Veterinary Record, 126: 210-212.

Milton, S., and Dean, R., (1993). Consumption of termites by captive ostrich chicks. Suid Afrikaanse Tydskrift Natuurnavinging, 23: 58-60.

Minero, M., Canali, E., Ferrante, V., Carenzi, C., 2001. Measurement and time domain analysis of heart rate variability in dairy cattle. Vet Rec., Dec 2001; 149: 772 - 774.

Misson, B.H., (1976). The effects of temperature and relative humidity on the thermoregulatory responses of grouped and isolated neonate chicks. Journal of Agricultural Science (Cambridge) 86: 35-43

Mitchell M.A. & Kettlewell, P.J., (2002). Nuevos sistemas de recogida y transporte de pollos para la mejora de bienstar de las aves y la calidad del producto. In Proc. de II Congresso de Produccion y Sanidad Animal ExpoAviga - XXXVIII WPSA Symposium, Barcelona 5th-8th November 2002 pp63-73.

Mitchell M.A., Kettlewell P.J. and Maxwell M.H.,(1992). Indicators of physiological stress in broiler chickens during road transportation. Animal Welfare 1: 91-103.

Mitchell M.A., Kettlewell P.J., Sandercock D.A., Maxwell M.H., and Spackman D., (1996b). Physiological stress in ostriches during road transportation. In: “Improving our understanding of ratites in a farming environment". Proceedings of an International Conference, (Deeming D.C., Ed.), 27-29th. March, University of Manchester, UK, 79-80.

Mitchell, M. A., Kettlewell, P. J., Hunter, R. R. & Carlisle, A. J. (2001) Physiological stress response modeling - application to the broiler transport thermal environment. In: Proceedings of the 6th International Livestock Environment Symposium, Louisville, Kentucky, U.S.A., 21st-23rd May 2001. Edited by Stowell, R. R., Bucklin, R. & Bottcher, R. W. pp 550-555.

Mitchell, M.A. & Kettlewell, P.J. (1993) Catching and transport of broiler chickens. In Proceedings of the IVth European Symposium on Poultry Welfare. Ed. C.J.Savory and B.O.Hughes. UFAW pp 219-229.

Mitchell, M.A. & Kettlewell, P.J. (1998). Physiological stress and welfare of broiler chickens in transit: Solutions not problems ! Poultry Science 77 (12) 1803-1814.

Mitchell, M.A., (1999). Muscle abnormalities - pathophysiological mechanisms. In: Poultry Meat Science. Edited by Richardson, R. I. & Mead, G. C. Poultry Science Symposium Series Vol. 25, CABI Publishing, CABI International, Oxon, UK. pp 65-98.

Mitchell, M.A., (2002). Chick transport and welfare in Practical aspects of commercial incubation in poultry. Ed. D.C. Deeming, Incubation and Fertility Research Group (WPSA Working Party 6 [Reproduction]), Published Ratite Conference Books, Lincolnshire 2002.

Mitchell, M.A., Carlisle, A.J., Hunter, R.R. and Kettlewell, P.J. (2000) The responses of birds to transportation. In the Proceedings of the World Poultry Congress, Montreal, Canada, 22nd-24th August 2000, pp 1-14.

Mitchell, M.A., Carlisle, A.J., Hunter, R.R. and Kettlewell, P.J., (1997). Welfare of broilers during transportation: cold stress in winter - causes and solutions. Proceedings of the Fifth European Symposium on Poultry Welfare. Edited by P.Koene and H.J. Blokhuis, WPSA, University of Wageningen and Institute of Animal Science and Health, Netherlands pp49-52.

Mitchell, M.A., Hunter, R.R., Kettlewell, P.J., and Carlisle, A.J. (1998a). Body temperature responses to the thermal micro-environment in transit from farm to slaughter. Poultry Science 77 (supplement 1) 110

Mitchell, M.A., Kettlewell, P.J., Carlisle, A.J. and Matheu,C. (1996a). The use of apparent equivalent temperature (AET) to define the optimum thermal environment for broilers in transit. Poultry Science 75 (Supplement 1): 18.

Mitchell, M.A., Kettlewell, P.J., Hoxey, R.P. and Macleod, M.G. (1998b). Heat and moisture production of broilers during transportation. A whole vehicle direct calorimeter. Poultry Science 77 (supplement 1) 4

Moberg, G.P. and Mench, J.A. (2000) *The Biology of Animal Stress.* Wallingford, C.A.B.I.

Monin G., (1988). Stress d'abbattage et qualité de la viande. Recueil de Medecine Vétérinarie, 164 (10) : 835-842.

Montero, D, Izquierdo, MS, Tort, L., Robaina, L., Vergara, JM (1999). High stocking density produces crowding stress altering some physiological and biochemical parameters in githead seabream, *Sparus aurata*. Fish Physiology and Biochemistry 20, 53-60.

Morisse, J. P., 1999. Animal welfare, an important objective. Rivista di Coniglicoltura. 1999. 36: 1, 20-27.

Moore, M.C., Thompson, C.W. and Marler,,C.A., (1991). Reciprocal changes in corticosterone and testosterone levels following acute and chronic handling stress in the tree lizard *Urosaurus ornatus.* Gen. Comp. Endocrinol. 81: 217-226.

More,S.J., (1996). The performance of farmed ostrich chicks in eastern Australia. Preventive Veterinary Medicine, 29: 91-106

Morera P., Kuzminsky G., and Finzi A., (1991). Effetto della manipolazione su alcuni parametri fisiologici del coniglio sottoposto a stress termico. Rivista di Coniglicoltura, 10: 39-41.

Moritz, J. (1995). Untersuchungen zur Transportmortalität von der Luftfragt importierten Reptilien und Amphibien. TVT Nachricht 1/1995, 3-8.

Morton D.B., Jennings M., Batchelor G.R., Bell D., Birke L., Davies K., Eveleigh D.G., Heath M., Howard B., Koder P., Philips P., Poole T., Sainbury A.W., Sales G.D., Smith D.J.A., Mourisse J.P. e Maurice R., (1997). Influence of stocking density on the behaviour in fattening rabbits kept in intensive conditions. Applied Animal Behaviour Science, 4: 351-357.

Mourisse J.P., (1977). Etude des relations entre pathologie respiratoire et environnement dans un elevage de reproduction de lapins de chair. Recueil de Medecine Veterinaire, 153 (12) : 915-922.

Mourisse J.P., (1978). Action d'un agent irritant (NH3) sur la pathogenie d'une affection respiratoire experimentale a Pasteurella multocida chez le lapin. Bulletin d'Information Station Experimentale d'Aviculture de Ploufragan, 18 (1) : 32-38.

Mourisse J.P., (1999). Benessere animale, obiettivo prioritario. Rivista di Coniglicoltura, 1: 20-27.

Mourisse J.P., Boilletot E., and Martrenchar A., (1999). Preference testing in intensively kept meat production rabbits for straw on wire grid floor. Applied Animal Behaviour Science, 64: 71-80.

Mugford, R.A. (1977). External influences on the feeding of carnivores IN: M R Kare and O Maller (eds.) *The chemical senses and nutrition* New York: Academic Press, pp. 25-50.

Munro, A.L.S., (2001). The Aquatic Environment, in Fish Pathology, Ed RJ Roberts. pp 1-11. WB Saunders, London.

Murakami, H., Akiba,Y. and Horiguchi, M. (1992). Growth and utilization of nutrients in newly-hatched chick with or without removal of residual yolk. Growth, Development and Aging, 56, 75-84.

Mykytowycz R., (1973). Reproduction in mammals in relation to environmental odours. Journal of Reproduction and Fertility, (Suppl. 19): 433-446.

Mykytowycz R., 1958. Social behaviour of an experimental colony of wild rabbit. CSIRO Wildlife Research, 3: 7-25.

Nevill, C. H, Friend T. H. and Toscano, M. J. (in press). Survey of transport environments of circus tiger acts, Journal of Zoo and Wildlife Medicine (in press).

Nevill, C.H. and Friend, T.H. (2003). The behaviour of circus tigers during transport. Applied Animal Behaviour Science 82: 329-337.

New Zealand Animal Welfare Advisory Committee, (1994). Code of Recommendations and Minimum Standards for the Welfare of Animals Transported within New Zealand. Code of Animal Welfare No. 15, Ministry of Agriculture, Wellington, New Zealand.

New Zealand Animal Welfare Advisory Committee, (1996). Amendments to the Code of Recommendations and Minimum Standards for the Welfare of Animals Transported within New Zealand. Code of Animal Welfare No. 15, Ministry of Agriculture, Wellington, New Zealand.

Nichelmann, M., Baranyiová, E., Goll, R. and Tzschentke, B. (1986) Influence of feather cover on heat balance in laying hens (Gallus domesticus). J. therm. Biol. 15:121-126.

Nicol, C., Saville-Weeks, C. (1993) Poultry handling and transport. In Livestock Handling and Transport. Ed. T. Grandin. CAB International, UK pp 273-287.

Nicol, C.J. (1992). Effects of environmental enrichment and gentle handling on behaviour and fear responses of transported broilers. Applied Animal Behaviour Science, 33: 367-380.

Nicol, C.J. and Scott, G.B. (1990). Pre-slaughter handling and transport of broiler chickens. *Applied Animal Behaviour. Science*. **28**: 57-73.

Nicol, C.J., and Scott, G.B. (1990). Preslaughter handling and transport of broiler chickens. Applied Animal Behaviour Science, 28: 57-73.

Nilipour, A.H. (1996). Live haul, making or losing money ? *World Poultry* **12** (12) 49-53.

Nilipour, A.H. (2002) Poultry in transit are a cause for concern. *World Poultry,* **18** (**2**): 30-33.

Noy, Y., Uni, Z. and Sklan, D 1996. Routes of yolk utilisation in the newly hatched chick. British Poultry Science, 37, 987-996.

Ou, Y and Li, J., (1996). Tests on the transportation of live parent mullet. Marine fisheries/Haiyang Yuye. Shanghai, vol. 18, no. 1, pp. 8-12.

Ouedraogo, A., Le Niendre, P. (1999). L'homme et l'animal : un débat de société, INRA Editions, 121 aris, 128 pp.

Ouhayoun J., (1992). La qualità della carne di coniglio. Rivista di Coniglicoltura, 5: 37-45.

Ouhayoun J., and Lebas F., (1995). Effects de la diète hydrique, du transport et de l'attente avant l'abattage sur le composantes du rendement et sur les caractèristiques physico-chimiques musculaires. Viandes Prod. Carnès, 16: 13-16.

Owen R.A., Fullerton J. and Barnum D.A. ,(1983). Effects of transportation, surgery, and antibiotic therapy in ponies infected with Salmonella. Am.J.Vet Res., 44, 46-50.

Owens C.M. and Sams, A.R. (2000) The influence of transportation on turkey meat quality. Poultry Science 79: 1204-1207.

Owens, C. M., Matthews, N. S., and Sams, A. R. (2000 a). The use of Halothane gas to identify turkeys prone to developing pale, exudative meat when transported before slaughter. Poultry Sci. 79: 789-795.

Owens, C. M., McKee, S. R., Matthews, N. S. and Sams, A. R., (2000 b). The development of Pale, Exudative meat in two genetic lines of turkeys subjected to heat stress and its prediction by Halothane screening. Poultry Sci. 79: 430-435.

Paci G., Marzoni Fecia di Cossato M., Piloni S., and Bagliacca M., (1999). Effetto della stagione e della tecnica di allevamento sulle prestazioni produttive e sulla qualità della carne di coniglio. Rivista di Coniglicoltura, 9: 30-36.

Paleari M.A., Corsico P., and Beretta G., (1995). The ostrich: breeding, reproduction, slaughtering and nutritional value of the meat. Fleischwirtschaft, 75(9), 1120-1123.

Panda, B. and Singh, R. P., (1990) Developments in processing quail meat and eggs. World`s Poult. Sci. J. 46: 219-234.

Panda, B., Ahuja, S. D., Shrivastav, A. K.,Singh, R. P., Agarwal, S. K. and Thomas, P. C. (1987). Meat and meat products. In: Quail Production Technology, Division of Technology Transfer, Central Avian Research Institute, Izatnagar, India, 31 pp.

Parrott, R.F., Hall, S.J.G. and Lloyd, D.M. (1998a). Heart rate and stress hormone responses of sheep to road transport following two different loading responses. *Animal Welfare*, 7, 257-267.

Parrott, R.F., Hall, S.J.G., Lloyd, D.M., Goode, J.A. and Broom, D.M., (1998b). Effects of a maximum permissible journey time (31 h) on physiological responses of fleeced and shorn sheep to transport, with observations on behaviour during a short (1 h) rest-stop. *Animal Science*, 66, 197-207.

Parrott, R.F., Lloyd, D.M., Brown, D.M. (1999). Transport stress and exercise hyperthermia recorded in sheep by radiotelemetry. *Animal Welfare*;8, 27-34.

Patak, A., and Baldwin, J., (1996). Muscle degeneration in common wild emus. In: “Improving our understanding of ratites in a farming environment.” Proceedings of an International Conference, University of Manchester, UK 27-29th. March, (Deeming D.C., Ed.), 12-13.

Paxton, R., Gist, D.H., Umminger, B.L,, (1984). Serum cortisol levels in thermally-acclilmated goldfish (*Carassius auratus*) and killifish (*Fundulus heteroclitus*): implications in control of hepatic glycogen metabolism. Comparative Biochemistry and Physiology 78B, 813-816.

Payne H., (1993). Welfare of ostriches and other ratites during transport. State Veterinary Journal, 3 (4): 8-12.

Payne H., (1994). Welfare of ostriches and other ratites during transport. Live Animal Trade and Transport Magazine, September 1994, 45-48.

Pearse, T., Fennessy, P., (1989). Wintering red weaner deer indoors. The Deer Farmer 62: 55-56.

Pfitzer S., and Lambrechts H., (2001). The use of haloperidol during transport of adult ostriches. Journal of South African Veterinary Association, 72 (1): 2-3.

Phillips P.K., and Sanborn A.F., (1994). An infrared, thermographic study of surface temperature in three ratites - ostrich, emu and double wattled cassowary. Journal of Thermal Biology, 19: 423-430.

Phillips, J.G., Butler, P.J., and Sharp, P.J., (1985). Physiological Strategies in Avian Biology. Blackie UK, Chapman & Hall, USA.

Pickering , A.D. and Pottinger, J.G., (1985). Factors influencing blood cortisol levels of brown trout under intensive culture conditions. *Current Trends in Comparitive Endocrinology*. (eds B. Lofts and W.N. Holms), Hong Kong University Press, Hong Kong, 1239-1242.

Pickering, A.D. and Pottinger, T.G., (1989). Stress responses and disease resistance in salmonid fish: Effects of chronic elevation of plasma cortisol. Fish Physiology and Biochemistry 7, 253-258.

Pickering, A.D., (1992). Rainbow trout husbandry: Management of the stress response. In: The rainbow trout. (ed G.A.E.Gall), pp. 125-139. Amsterdam: Elsevier.

Pickering, A.D., Pottinger, T.G., Christie, P. (1985). Recovery of the brown trout, Salmo trutta L., from acute handling stress: a time course study. J. Fish Biol. 20, 229-244.

Pickering, A.D., Pottinger, T.G., Sumpter,J.P., Carragher,J.F., and Le Bail,P.Y.,(1991). Effects of acute and chronic stress on the levels of circulating growth hormone in the rainbow trout, Oncorhynchus mykiss. *Gen.Comp.Endocrinol.* **83**, 86-93.

Pingard A. and Brelurut A., (1998). Conduite d'élevage et dominantes pathologiques des cervidés en France. Le Point Veterinaire, 29 (190): 19-29.

Piper, R.G. et al. (1982). Fish hatchery management. Washington, D.C. US Department of the Interior, Fish and Wildlife Service, pp 348-371.

Pitman, VM, Gutreuter, S (1993). Iitial poststocking survival of hatchery-reared fishes. North American Journal of Fisheries Management 13, 151-159.

Podberscek A.L., Blackshaw J.K. E Beattie A.W., (1991a). The behaviour of group penned and individually caged laboratory rabbits. Applied Animal Behaviour Science, 28: 353-363.

Podberscek A.L., Blackshaw J.K. E Beattie A.W., (1991b). The effects of repeated handling by familiar and unfamiliar people on rabbits in individual cages and group pens. Applied Animal Behaviour Science, 28: 365-373.

Pollard J., and Littlejhon R.P., (1998). Effects of winter housing, exercise and dietary treatments on the behaviour and welfare of red deer (*Cervus elaphus*). Animal Welfare, 7: 45-56.

Pollard J., Stevenson-Barry J., and Littlejhon R.P., (1998). Behaviour and meat quality at an Otago deer slaughter plant. Proceedings of a Deer Course for Veterinarians No. 15, Dunedin, 219-225.

Pollard J., Stevenson-Barry J., and Littlejhon R.P., (1999). Factors affecting behaviour, bruising and pH_u in a deer slaughter premises. Proceedings of the New Zealand Society of Animal Production, 59: 148-151.

Pollard J.C. and Wilson P.R., (2002). Welfare of farmed deer in New Zealand. 1. Management practices. New Zealand Veterinary Journal, 50 (6): 214-220.

Pollard J.C., and Littlejohn R.P., (1994). Behavioural effects of light conditions on red deer in a holding pen. Applied Animal Behaviour Science, 41: 127-134.

Pollard J.C., and Littlejohn R.P., (1995). Effects of lighting on heart rate and positional preferences during confinement in farmed red deer. Animal Welfare, 4: 329-337.

Pollard, J.C., Littlejhon, R.P., and Suttie, J.M., (1993). Effects of isolation and mixing of social groups on heart rate and behaviour of red deer stags. Applied Animal Behaviour Science, 38: 311-322.

Pollard, J.C., Littlejhon, R.P., and Suttie, J.M., (1994). Responses of red deer to restraint in a Y-maze. Applied Animal Behaviour Science, 39: 63-71.

Pollard, J.C., Littlejohn, R.P., (1996). The effects of pen size on the behaviour of farmed red deer stags confined in yards. Applied Animal Behaviour Science 47: 247-253.

Pollard, J.C., Pearse, A.J.T., Webster, J.R., Drew, K.R., Asher, G. W., Stevens, D.R., Stevenson-Barry, J.M., Mackintosh, C.G., Matthews, L.R., Fisher, A.D., Fisher M.W, Stafford, K.J., Wilson P.R., Tacon, J.R., and Scott I., (2002). Review of Deer Welfare. Confidential Report to DeeResearch, New Zealand.

Poole, (1999) Universities Federation for Animal Welfare (UFAW) Handbook on The Care & Management of Laboratory Animals (1999) 7th Edition (Two volumes) Pub. Blackwell Science Ltd., ISBN 0-632-05131-0.

Poultry Bulletin (2002) Chicken market quarterly, January 2002, Ed D. Taylor, National Farmers Union, Newmarket, Suffolk, p15.

Poultry World (2001) EU facts and forecasts. Poultry World, September 2001 14-15.

Prescott, M.J., (2002). Counting the cost - Welfare implications of the acquisition and transport of non-human primates for use in research and testing. Royal Society for the Prevention of Cruelty to Animals (RSPCA).

Prescott, N. B., Berry, S., Haslam, S. and Tinker, D. B. (2000), Catching and Crating turkeys: Effects on carcass damage, heart rate, and other welfare Parameters. J. Appl. Poutry Res. 9: 424-432

Price S., Sibly R.M., and Davies M.H., (1993). Effects of behaviour and handling on heart rate in farmed red deer. Applied Animal Behaviour Science, 37: 11-123.

Purdue D., (1984). The effect of transport and fasting on physiological indices of stress and subsequent meat quality of the rabbit. M.Sc.Thesis, University of Bristol.

Putter, G., (1996), Provenricular impaction and a non-surgical way of dealing with this problem. In: "Improving our understanding of ratites in a farming environment. Proceedings of an International Conference, 27-29th. March, University of Manchester, UK, (Deeming D.C., Ed.), 49-50.

Quinn P.J, B.K.Markey; M.E. Carter; W.J. Donnelley and F.C. Leonard: Veterinary Microbiology and Microbial Diseases, Blackwell Science, 2000.

Quinn, A.D. & Baker, C.J. (1997) An investigation of the ventilation of a day-old chick transport vehicle. Journal of Wind Engineering and Industrial Aerodynamics, 67 & 68: 305-311.

Quinn, A.D., Kettlewell, P.J., Mitchell, M.A. & Knowles, T. G.. (1998) Air movement and the thermal microclimates observed in poultry lairages. British Poultry Science, 39: 469-476.

Qureshi, A.A., (1991). Losses due to dehydrated broiler chicks. World Poultry (Misset) 7 (4): 75-79.

Radostits, O.M., Gay, C.C., Blood, D.C. and Hinchcliff, K.W., (2000). *Veterinary Medicine: A Textbook of the Diseases of Cattle, Sheep, Pigs, Goats and Horses*, *9th Edition*. W.B. Saunders, London.

Raines A.M., (1998). Restraint and housing of ratites. Veterinary Clinics of North America, Food Animal Practice, 14 (3): 387-399.

Randall, J.M. and Bradshaw, R.H. (1998). Vehicle motion and motion sickness in pigs. *Animal Science*., 66, 239-245.

Ranucci S., Morgante M., Diverio S., Costarelli S., Beghelli D., and Duranti E., (1996). Blood constituents and clinical findings in captured fallow deer. International Workshop "Resources utilization in Fallow Deer", 20-22 June 1995, Montepaldi (FI), Supplemento alle Ricerche di Biologia della Selvaggina, XXV: 209-217.

Rashotte M E, Smith J C, Austin T, Castonguay T W and Jonsson L 1984 Twenty-four-hour free feeding patterns of dogs eating dry food *Neurosciences and Biobehavioural Review* 8: 205-210.

Redding, JM, Schreck, CB (1983). Influence of ambient salinity on osmoregulation and cortisol concentration in yearling coho salmon during stress. Transactions of the American Fisheries Society 112, 800-807.

Reed, H.J., Wilkins, L.J., Austin, S.D. and Gregory, N.G. (1993). The effects of environmental enrichment during rearing on fear reactions and depopulation trauma in adult caged hens. Applied Animal Behaviour Science, 36: 39-46.

Rehbinder, C and Edquist, L-E., (1981). Influence of stress on some blood constituents in reindeer (Rangifer tarandus L). Acta. Vet. Scand. 22: 480-492.

Rehbinder, C. (1975). Calf mortality of the Ängesås reindeer herd. Nord. Vet. Med. 27: 241-252.

Rehbinder, C. (1990). Management stress in reindeer. Rangifer, Special Issue No. 3, 267-288.

Reimers, E. (1997). Rangifer population ecology: a Scandinavian perspective. Rangifer, 17: 105-118.

Reiner G., Seitz K., Dzapo V., (1996). A survey of farming environment and ostrich behaviour in Germany. In: “Improving our understanding of ratites in a farming environment. Proceedings of an International Conference, (Deeming D.C., Ed.), 27-29th. March, University of Manchester, UK,

Roberts R.J. & Rodger H.D. (2001) Pathophysiology and Systemic Pathology of Teleosts, in Fish Pathology, Ed RJ Roberts. pp 55-132 WB Saunders London.

Robertson, L, Thomas, P, Arnold, C.R., (1988). Plasma cortisol and secondary stress responses of cultured red drum (*Sciaenops ocellatus*) to several transportation procedures. Aquaculture 68, 115-130.

Rommers J.M. and Meijerhof R., (1996). The effect of different floor types on footpad injuries of rabbit does. 6th World Rabbit Congress, Toulose, vol. 2: 431-436.

Rosell J.M., (1996). Rabbit ortality survey. Necropsy findings in the field during the period 1989-1995. 6th World Rabbit Congress, Toulose, 3:107-112.

Ross Breeders (1996) Producing quality broiler meat. Ross Broiler Management Manual.

Rushen, J. (1986a). Aversion of sheep for handling treatments: paired choice experiments. *Applied Animal Behaviour Science* 16, 363-370.

Rushen, J. (1986b). The validity of behavioural measure of aversion: a review. *Applied Animal Behaviour Science* 16, 309-323.

SABS 0331 Edition 1 (2000). South African Standard Code of Practice regarding the translocation of certain species of wild herbivore. South African Bureau of standards, Pretoria.

Sales J. and Mellet F.D., (1996). Research Note. Post-mortem pH decline in different ostrich muscles. Meat Science. 42 (2): 235-238.

Sambraus H.H., (1995). Behavioural disorders in the food intake of ostriches. Berliner und Munchener Tierarztliche Wochenschrift , 108: 344-346.

Sambraus H.H., (1996). Feather pecking in ostriches in captivity. Tierarztliche Umschau, 50: 108-111.

Samson J., (1996). Behavioural problems in farmed ostriches in Canada. Canadian Veterinary Journal, 37: 412-414.

Sandford, G., Banister, K.E. (1991). The trade in tropical freshwater fish in UK. RSCPA.

Sanotra, G.S., Lund, J.D., Ersboll, A.K., Petersen, J.S. and Vestergaard, K.S. (2001). Monitoring leg problems in broilers: a survey of commercial broiler production in Denmark. World’s Poultry Science Journal 57, 55-69

Sauer, E.G.F and Sauer, E.M., (1966). Social behaviour of the South African Ostrich, *Struthio camelus australis*. Ostrich, 6: 183-191.

SCECPAFP, 2003. Standing Committee of the European Convention for the Protection of the Animals kept for Farming Purposes. Recommendation concerning ratites. Struzzo e dintorni (Ostrich and around), 48/April, 19-23.

Schlenker, G.R. & Muller, W. (1997) The transportation of day-old chicks by aircraft with regard to animal welfare. Berliner und Munchener Tierarztliche Wochenschrift, 110 (9): 315-319.

Schlüter, H. and Kramer, M. (2001). Epidemiologische Beispiele zur Seuchenausbreitung. *Dtsch. Tierärztl. Wschr.* 108, 338-343.

Schneider, V. (2000) Einfluss der Fang und Transportbedingungen auf die Transportverluste bei Masthuehnern. D Vet Med dissertation, Tieraerztliche Hochschule Hannover.

Schreck, C.B., Jonsson, L., Feist,G., & Reno,P. (1995). Conditioning improves performance of juvenile Chinook salmon, *Oncorhynchus tschawytscha*, to transportation stress. *Aquaculture* 135, 99-110.

Schütz, C (2003). Transport losses of CITES protected and non-protected animal species. Report from the Federal Agency for Nature Conservation. Identification of transport sensitive CITES protected species, BfN, Report No. 90, Bonn, Germany.

Scobie-Trumper P., (1995). Animal Handling and Manipulation. In: "Laboratory Animals. An introduction for experimenters." (Tuffery A.A., Ed.), John Wiley & Sons Ltd., Chichester, England, 233-254.

Scope, A., Filip, T., Gabler, C. and Resch, F. (2002) The influence of stress from transport and handling on hematologic and clinical chemistry blood parameters of racing pigeons (*Columba livia domestica*). Avian Diseases 46: 224-229.

Scott, G. B., (1993) Poultry handling: A review of mechanical devices and their effect on bird welfare. World´s Poultry Sci. J. 49: 44-57.

Scott, J.P. (1962) Critical periods in behavioural development *Science* 138: 949-958.

Scott, J.P.and Fuller J L (1965) *Genetics and the Social Behavior of the Dog* Chicago: University of Chicago Press.

Seal U.S., Verme, L.J., Ozoga, J.J. and Plotka, E.D., (1983). Metabolic and endocrine responses of white-tailed deer to increasing population density. Journal of Wildlife Management, 47 (2): 451-462.

Seamer, D.J., (1986). The welfare of deer at slaughter in New Zealand and Great Britain. The Veterinary Record, 118: 257-258.

Selwyn P., and Hathaway S., (1990). A study on the prevalence and economic significance of diseases and defects of slaughtered farm deer. New Zealand Veterinary Journal, 38: 94-97.

Selye, H. (1980). The stress concept today. In: Kutash, I.L., Schlesinger, L.B. et al. (Eds): Handbook of stress and anxiety. Jossey-Bass Publisher, San Francisco, pp. 127-143.

Shakespeare, A.S., (1996). Clinical cases illustrating causes of recumbent ostriches. In: "Improving our understanding of ratites in a farming environment." Proceedings of an

International Conference, University of Manchester, UK 27-29th. March, (Deeming D.C., Ed.), 55-57.

Shakespeare. A.S., (1995). Recumbency in ostriches. Compendium of Continuing Education for the Practicing Veterinarian, 17: 1440.

Sherwin, C.M., Kestin, S.C., Nicol, C.J., Knowles, T.G., Brown, S.N., Reed, H.J., and Warriss, P.D. (1993). Variation in behavioural indices of fearfulness and fatigue in transported broilers. British Veterinary Journal, 149, 571-578.

Short D.J., (1967). Handling, sexing and palpating laboratory animals. In: "Husbandry of laboratory animals", (Conalty M.L., Ed.), Academic Press, London, UK, Universities Federation for Animal Welfare (UFAW), (1988). Management and Welfare of Farm Animals (3rd Ed.), Bailliere Tindall, London, U.K., 3-16.

Simplicio J.B., Cervera C., and Blas E., (1988). Effect of two different diets and temperatures on the growth of meat rabbit. Proceedings of 4th World Rabbit Congress, Budapest, 3: 74-78.

Singh, R. P., Shrivastav A. K. and Panda, B. (1980) Studies on slaughter characteristics of Japanese quail (*Coturnix xotunix japonica*) at different stages of growth. Indian Poultry Gazette 64: 12-17

Skadhauge, E., (1981). Osmoregulation in Birds. Springer-Verlag, Berlin-Heidelberg-New York, USA.

Skadhauge, E., and Dawson, A. (1999)."Physiology". In: "The ostrich: biology, production and health." (Deeming, D.C., Ed.), CABI International, UK, 51-82.

Skadhauge, E., Dawson, T.J., Prys-Jones, R., and Warui, C.N., (1996). The role of the kidney and gut in osmoregulation. In: "Improving our understanding of ratites in a farming environment." Proceedings of an International Conference, University of Manchester, UK 27-29th. March, (Deeming D.C., Ed.), 115-122.

Skoglund, E. (1997). Drivning av ren. National Board of Agriculture (in Swedish).

Smart, A.C and Bride, I.G. (1993). The UK Trade in Live Reptiles and Amphibians. A report to the RSPCA on the nature and status of the reptile and amphibian pet trade between 1980 and 1992.

Smart,G.R. (1981). Aspects of water quality producing stress in intensive fish culture. In: *Stress and Fish.* (ed A.D.), pp. 277-293. New York: Academic Press.

Smith J.H, and Bubenik G.A., (1990). Plasma concentrations of glucocorticoids in white-tailed deer: the effect of acute ACTH and dexametasone administration. Canadian Journal of Zoology, 68: 2123-2129.

Smith R.F., and Dobson H., (1990). Effect of pre-slaughter experience on behaviour, plasma cortisol and muscle pH in farmed red deer. The Veterinary Record, 126: 155-158.

Sosnicki, A. A., Greaser, M. L., Pietrzak, M., Pospiech, M. and Sante, V. (1998) PSE-like syndrome in breast muscle of domestic turkeys: A review. J. Muscle Foods): 13-23.

SOU (2003) – 6. Swedish report on Animal transport

Specker, JL, Schreck, CB (1980). Stress responses to transportation and fitness for marine survival in coho salmon (*Oncorhynchus kisutch*) smolts. Can. J. Fish. Aquat. Sci. 37, 765-769.

Spraker T.R., (1982). An overview of the pathophysiology of capture myophaty and related conditions that occur at the time of wild animals. In: “Chemical Immobilisation of North American Wildlife” (Nielsen L., Haigh J.C., and Fowler M.E., Eds), Wisconsin Humane Society, Milwaukee, Wisconsin, 83-118.

Stauffacher M., (1992). Group housing and enrichment cages for breeding fattening and laboratory rabbits. Animal Welfare, 1: 105-125.

Stauffacher M., and Turner R.J., (1993). Refinement in rabbit husbandry. Second Report of the BVAAWF/FRAME/RSPCA/UFAW Joint Working Group on Refinement. Laboratory Aniamals, 27: 301-329.

Staurnes, M; Sigholt, T; Pedersen, HP; Rustad, T (1994). Aquaculture, vol. 119, no. 4, pp. 381-391.

Stedman, N. L., Brown, T. P., and Rowland, G. N. (1998) Intravascular Cartilaginous Emboli in the spinal Cord of Turkeys. Avian Diseases 42: 423-438.

Steinmetz, M., Puetsch, M. and Bisschopnik, T. (1998). Untersuchungen zur Transportmortalität beim Import von Vogelen und Reptilien nach Deutchland. Mit einer studie zu Prä-Export-Bedingungen in Tanzania. Bundesamt für Naturschütz, Germany .

Stevenson-Barry J.M., (2000). Systems for quality venison. Proceedings of the NZVA Deer Branch Conference, l17: 117-122.

Stewart, J.S., (1994). Ostrich behaviour and behavioural problems. Proceedings of the Annual Conference of the Association of Avian Veterinarians, 104-109.

Strange, R.J and Schreck, C.B. (1978). Anesthetic and handling stress on survival and cortisol concentration in yearling chinook salmon (Oncorhynchus tshawytscha). Journal of Fisheries Research Board Canadian 35, 345-349.

Strange, R.J. (1980) Acclimation temperature influences cortisol and glucose concentrations in stressed channel catfish. Trans.Am.Fish.Soc. 109, 298-303.

Strange, R.J., Schreck, C.B., & Ewing, R.D. (1978) Cortisol concentrations in confined juvenil chinook salmon (Oncorhynchus tshawytscha). Transactions of the American Fisheries Society 107, 812-819.

Strange, RJ, Schreck, CB, Ewing, RD (1977). Cortisol concentrations in confined juvenile chinook salmon (Oncorhynchus tshawytscha). Transaction of the American Fisherie Society 107, 812-819.

Svobodova, Z; Kalab, P; Dusek, L; Vykusova, B; Kolarova, J; Janouskova, D (1999). Acta Veterinaria (Brno) Vol. 68, pp. 265-274.

Swarbrick, O. (1986). The welfare during transport of broilers, old hens and replacement pullets. In: (ed. T.E. Gibson) The welfare of Animals in transit. British Veterinary Association. Animal Welfare Association, London, 82-97.

Swedish Agricultural Statistic (2002). Jordbruksstatistik årsbok 2002, tabell 15.6.

Takashima, F (1996). Proceedings of the conference of IIR, Commission C2 Bordeaux – Refrigeration and Aquaculture. pp. 221-235.

Takeda, T. and Itazawa, Y. (1983) Possibility of applying anaesthesia by carbon dioxide in the transportation of live fish. Bull. Jap. Soc. Sci. Fish 49: 725-731.

Takeda, T., Tsuji, T. and Itazawa, Y. (1989). Facilitation of housing capacity for red porgy by drop in water temperature. Nippon Suisan Gakkaishi 55: 1011-1015.

Tamlyn, J., Starr, J.R. (1987). Monitoring the environment during transportation of day olds. International Hatchery Practice 6 (1): 11-15

Tanaka, A. & Xin, H. (1997a). Energetics, mortality, and body mass change of breeder chicks subjected to different post-hatch feed dosages. Transactions of the American Society of Agricultural Engineers, 40(5): 1457-1461.

Tanaka, A. & Xin, H. (1997b) Effects of structural and stacking configuration of containers for transporting chicks in their microenvironment. Transactions of the American Society of Agricultural Engineers, 40 (3): 777-782.

Tarrant, P.V. (1989). The effects of handling, transport, slaughter and killing on meat quality and yield in pigs – a review. *Irish J. Food. Sci. Tech.*, 13, 79-107.

Taubert, E., Wicke, M., Von Lengerken, G. and Troeger, K. (2002) Zusammenhänge zwischen externen Belastungsfaktoren und der Fleischqualität von Puten. Fleischwirtschaft 2/2002: 96-99.

Taylor, H.H, Paterson B.D, Wong R.J, and Wells R.M.G. (1997). Physiology and live transport of lobsters: report from a workshop, Marine and Freshwater Research, 48 (8): 817-822.

Taylor, M.H. and Helbacka, N.V.L. (1968). Field studies of bruised poultry. Poultry Science, 47: 1166-1169.

Tedford C., (1997). Great Learning experiences on Transporting Deer. The North American Deer Farmer. Spring, 21-25.

Thiry, E., Saliki, J., Bublot, M. and Pastoret, P.-P. (1987). Reactivation of infectious bovine rhinotracheitis virus by transport. *Comp. Immun. Microbiol. Infect. Dis.* 10, 59-63.

Thomas, R.E., Gharrett, J.A., Carls, M.G., Rice, S.D., Moles, A., & Korn,S. (1986) Effects of fluctuating temperature of mortality, stress, and energy reserves of juvenile coho salmon. *Trans.Am.Fish.Soc.* **115**, 52-59.

Thompson, A. L. (1964) A new dictionary of birds. London, Nelson

Tomasso, J.R., Davis,K.B., & Parker,N.C. (1981a) Plasma coticosteroid dynamics in channel catfish, Ictalurus punctatus (Rafinesque), during and after oxygen depletion. Journal of Fish Biology 18, 519-526.

Tomasso, J.R., Davis,K.B., & Simco,B.A. (1981b). Plasma corticosteroid dynamics in channel catfish (*Ictalurus punctatus*) exposed to ammonia and nitrite. *Canadian Journal of Fisheries and Aquatic Sciences* **38**, 1106-1112.

Tomasso, J.R., Davis, K.B. and Parker, N.C. (1980). Plasma corticosteroid and electrolyte dynamics of hybrid striped bass (white bass x striped bass) during netting and hauling. Proc World Maricult. Soc. 11, 303-310.

Torges, H. G. and Wegner, R. M. (1984) The effect of age and sex on broiler performance of heavy-strain quails (*Coturnix coturnix japonica*). Arch. F. Geflügelkunde 48, 57-65.

Toscano, M.J., Friend, T.H. and Nevill, C.H., (2001). Environmental conditions and body temperature of circus elephants transported during relatively high and low temperature conditions. Journal of Elephant Managers Association (JEMO) 12: 115-149.

Trunkfield, H.R. and Broom, D.M., (1990). The welfare of calves during handling and transport. *Applied Animal Behaviour Science* 28, 135-152.

Trunkfield, H.R. and Broom, D.M., Maatje, K., Wierenga, H.K., Lambooy, E. and Kooijman, J., (1991). Effects of housing on responses of veal calves to handling and transport. In: Metz, J.H.M. and Groenestein, C.M. (eds.) *New Trends in Veal Calf Production*, Pudoc, Wageningen, The Netherlands, 40-43.

Tuckwell C., (1995). Development of slaughter facilities for the South Australian deer industry. Technical Report n° 233, Primary Industries South Australia.

Tüller, R. (1997). Faustzahlen für Geflügelmast. In: Jahrbuch für die Geflügelwirtschaft 1997. Ulmer Verlag, Stuttgart.

UFAW, 1988. University Federation for Animal Welfare. Management and Welafare of Farmed Animals. Bailliere Tindall, London, 3rd Edn.

Uglow RF. Hosie DA, Johnson, I.T., Macmullen, P.H. (1986). Live handling and transport of crustacean Shellfish: An investigation of Mortalities. MAFF Commission Technical Report No. 280. Jan 1986. Sea Fish Industry Authority.

Uijttenboogaart, T. G. (1999) European Perspective on Poultry Slaughter Technology. Poultry Sci. 78: 295-297

Van der Hel, W., Verstegen, M.W.A., Henken, A.M., Brandsma, H.A. (1991) The upper critical temperature in neonatal chicks. Poultry Science 70: 1882-1887.

Van der Hel, W., Henken, A.M. (1990) Give newly hatched chicks a safe flight. Poultry International (Misset) 6 (1): 8-9.

Van Heerden, J., Hayes, S.C., and Williams, M.C., (1983). Suspected vitamin E-selenium deficiency in two ostriches. Journal of the South African Veterinary Association, 54: 53-54.

Van Hoof, J., (1979) Influence of ante- and peri- mortem factors on biochemical andphysical characteristics of turkey breast muscle. The Veterinary Q. 1, Jan. 1979: 29-36.

Van Putten, G. (1982). Handling of slaughter pigs prior to loading and during loading on a lorry. In: Moss, R. (ed.) *Transport of Animals Intended for Breeding, Production and Slaughter, Current Topics in Veterinary Medicine Animal Science* 18, 15-25. Martinus Nijhoff, The Hague.

Van Putten, G. and Elshof, W.J. (1978). Observations on the effect of transport on the well being and lean quality of slaughter pigs. *Animal Regulation Studies* 1, 247-271.

Van Ravenswaaij, C.M.A., Kolléè, L.A.A., Hopman, J.C.W., Stoelinga, G.B.A., and van Geijn, H. (1993). Heart rate variability. *Annals of Internal Medicine,* 118, 437-435.

Vastrade F.M., (1986). The social behaviour of free-ranging domestic rabbits (*Oryctolagus cuniculus L.*), Applied Animal Behaviour Science, 16: 165-177.

Vastrade F.M., (1987). Spacing behaviour of free-ranging domestic rabbits (*Oryctolagus cuniculus L.*), Applied Animal Behaviour Science, 18: 185-195.

Vastrade M.F., (1984). Ethologie du lapin domestique, *Orictolagus cuniculus* L. I. L'èthogramme. Cuni-Sciences, 2: 1-14.

Verde M.T., and Piquer J.G., (1986). Effect of stress on the corticosterone and ascorbic acid (Vitamin C) content on the blood plasma of rabbit. Journal of Applied Rabbit Research, 9 (4): 181-185.

Veronesi G., Veronesi G., Burlini F., Bretoni P., Canterani A., and Scozzoli M., (2000). Il trasporto degli struzzi (The ostrich transport). Struzzi e dintorni (Ostrich and around). 19: 20-34.

Vestergaard, K.S., (1996). Assessing animal welfare: the significance of causal studies of behaviour at the motivational level. *Acta Agric. Scand.* Sect. A., Anim. Sci. Suppl. 27, 61-63.

Vieira, S.L. & Moran, E.T., (1999). Effects of delayed placement and used litter on broiler yields. Journal of Applied Poultry Research, 8 (1): 75-81.

Vijayan, MM, Ballantyne, JS, Leatherland, JF (1990). High stocking density alters the energy metabolism of brook char, Salvelinus fontinalis. Aquaculture 88, 371-381.

Vinke, C. M. (1998). Research into the welfare situation of exotic animals during the process of animal trade. Utrecht: Animal Welfare Centre.

Vorster, B.J., (1984). Nutritional muscular dystrophy in a clutch of ostrich chickens. Journal of the South African Veterinary Association, 55: 39-40.

Waas J.R., Ingram J.R. and Matthews L.R., (1999). Real-time physiological responses of red deer to translocation. Journal of Wildlife Management, 63 (4): 1152-1162.

Wabeck, C. J. (1972). Feed and water withdrawal time relationship to processing yield and potential faecal contamination of broilers. Poultry Science 51, 1119-1121.

Wagner, E.J. Driscoll, D.M., (1994). Journal of Applied Aquaculture, vol. 4, no. 1, pp. 19-28.

Warriss P.D., (1990). The handling of cattle pre-slaughter and its effects on carcass and meat quality. Applied Animal Behaviour Science, 28: 171-186.

Warriss, P.D. and Knowles, T.G. (1993). Welfare aspects of broiler transport in the United Kingdom. Proceedings of the 4th International Symposium of American Society of Agricultural Engineering, University of Warwick, 6-9 July 1993.

Warriss, P.D., Bevis, E.A., Brown, S.N. and Edwards, J.E. (1992a). Longer journeys to processing plants are associated with higher mortality in broiler chickens. British Poultry Science, 33, 201-206.

Warriss, P.D., Bevis, E.A., Brown, S.N. and Edwards, (1992b). Responses of newly hatched chicks to inanition. Veterinary Record 130: 49-53.

Warriss, P.D., Bevis,E.A. and Brown,S.N.,(1990). Time spent by broiler chickens in transit to processing plants. Veterinary Record. 127, 617-619.

Warriss, P.D., Kestin, S.C., Brown, S.N. and Bevis, E.A., (1988). Depletion of glycogen reserves in fasting broiler chickens. British Poultry Science, 29, 149-154.

Warriss, P.D., Kestin, S.C., Brown, S.N., Knowles, T.G., Wilkins, L.J., Edwards, J.E., Austin, S.D. and Nicol, C.J., (1993). The depletion of glycogen stores and indices of dehydration in transported broilers. British Veterinary Journal, 149, 391-398.

Warriss, P.D., Knowles, T.G., Brown, S.N., Edwards, J.E., Kettlewell, P.J., Mitchell, M.A. & Baxter, C.A. (1999a) Effects of lairage time on body temperature and glycogen reserves of broiler chickens held in transport modules. Veterinary Record, 145: 218-222.

Warriss, P.D., Wilkins, L.J. and Knowles, T.G., (1999b). The influence of ante-mortem handling on poultry meat quality. In: Poultry Meat Science (eds R.I. Richardson and G.C. Mead). CAB International, Wallingford. Ch 9. pp.217-230.

Warriss P.D., Brown S.N., Bevis E.A., and Young C.S., (1986). The effects of fasting and transport on carcass yeld and meat quality in sheep. 32nd European Meeting of Meat Research Workers, August 24-29, Ghent, 99-102.

WATO, (1997). The Welfare of Animals (Transport) Order 1997. Statutory Instruments 1997 No 1480 the Ministry of Agriculture, Fisheries and Food.

Webb, RT (1958). Distribution of bluegill treated with tricaine methnesulfonate (MS-222). Progressive Fish-Culturist 20, 69-72.

Webster, A.J.F., Tuddenham, A., Saville, C.A. and Scott, G.B. (1993). Thermal stress on chickens in transit. British Poultry Science, 34: 267-277.

Wedemeyer, G.A. (1972) Some physiological consequences of handling stress in the juvenile coho salmon (Oncorhynchus kisutch) and steelhead trout (Salmo gairdneri). Journal of Fisheries Research Board Canadian 29, 1780-1783.

Wedemeyer, G.A. (1976) Physiological response of juvenils coho salmon (Oncorhynchus kisutch) and rainbow trout (Salmon gairdneri) to handling and crowding stress in intensive fish culture. Journal of Fisheries Research Board of Canada 33, 2699-2702.

Wedemeyer, GA (1992). World Aquaculture, vol. 23, no. 4, pp. 47-50.

Weeks C.A., (2000). Transport of deer: a review with particular relevance to red deer (Cervus elaphus). Animal Welfare, 19 (1): 63-74.

Weeks, C. & Nicol, C. (2000) Poultry handling and transport. In Livestock Handling and Transport. 2nd Edition Ed. T. Grandin. CAB International, UK pp 363-384.

Weisman, Y., Malkinson, M. Perl, S., Machany, S., Lublin, A., and Ashash, E., (1993). Paresis in young ostriches. The Veterinary Record, 132: 284.

Wensvoort, J., Kyle, D.J., Ørskov, E.R. and Bourke, D.A. (2001). Biochemical adaptation of camelids during periods where feed is withheld. Rangifer 21: 45-48.

Wesley, R.L. (1986a) How to avoid 99% of your downgrading. Turkey World 6: 24.

Wesley, R.L. (1986b) What causes 99% of your downgrading. Broiler Ind. 1: 148-149.

Westers, H (2001). Production. Pages31-89. In Wedemeyer G. Ed. Fish hatchery management. American Fisheries Society, Bethesda, Maryland.

Westerterp KR, Meijer EP, Rubbens M, Robach P, Richalet JP (2000) Operation Everest III: energy and water balance Pflugers Archiv-European Journal of Physiology 439, 483-488

Whittow, G.C., (1976). Regulation of body temperature. In: "Avian Physiology." Springer-Verlag, New York-Heidelberg-Berlin, (Sturkie P.D., Ed.), 146-173.

Wierup M, (1994) Control and prevention of Salmonella in livestock farms. In 16th Conf. OIE Regional Commission for Europe, Stockholm (Sweden) 28 June-1 July, 1994,pp 249-269

Wiklund, E. (1996). Pre-slaughter handling of reindeer (Rangifer tarandus L). Effects on meat quality. PhD thesis, Swedish University of Agricultural Sciences.

Wiklund, E., Malmfors, G., Lundström, K. and Rehbinder, C. (1996b). Pre-slaughter handling of reindeer bulls (Rangifer tarandus tarandus L.). Rangifer, 16: 109-117.

Wiklund, E., Rehbinder, C., Malmfors, G., Hansson, I. and Danielsson-Tham, M-L. (2001). Ultimate pH values and bacteriological conditions of meat and stress metabolites in blood of transported reindeer bulls. Rangifer, 21: 3-12.

Wiklund., E., Andersson, A., Malmfors, G. and Lundström, K. (1996a). Muscle glycogen levels and blood metabolites in reindeer (Rangifer tarandus tarandus L.) after transport and lairage. Meat Science, 42: 133-144.

Wiklund., E., Andersson, A., Malmfors, G., Lundström, K. and Danell, Ô. (1995). Ultimate pH values in reindeer meat with particular regard to animal sex and age, muscle and transport distance. Rangifer, 15: 47-54.

Williams, J.B., Siegfreid, W.R., Milton, S.J., Adams, N.J., Dean, W.R.J., Du Plessis, M.A., Jackson, S., and Nagy, K.A., (1993). Field metabolism, water requirements and foraging behaviour of wild ostriches in the Namib. Ecology, 74: 390-404.

Wilson P.R. and Stafford K.J. (2002). Welfare of farmed deer in New Zealand. 2. Velvet antler removal. New Zealand Veterinary Journal, 50 (6): 221-227.

Wilson, J.G. and Brunson, C.C. (1968). The effects of handling and slaughter method on the incidence of haemorrhagic thighs in broilers. Poultry Science, 47: 1315-1318.

Wilson, M., Warren, J.M. and Abbott, L., (1965) Infantile stimulation, activity and learning by cats *Child Development* 36: 843-853.

Withers, P.C., (1983). Energy, water and solute balance of the ostrich (*Struthio camelus*). Physiological Zoology, 56: 568-579.

Wolfensohn, S.E., (1997) Brief review of scientific studies of the welfare implications of transporting primates. Laboratory Animals, 31: 303-305.

Wood, E. (1985). Exploitation of coral reef fishes for aquarium trade. Report of the Marine Conservation Society.

Wotton S.B., and Hewitt L., (1999). Transportation of ostriches – a review. The Veterinary Record, 145: 725-731.

Wotton S.B., and Sparrey J., (2002). Stunning and slaughter of ostriches. Meat Science, 60: 389-394.

Xiccato G., (1994). Peso ed età al macello. Rivista di Coniglicoltura, 9: 15-.17.

Xin, H. & Harmon, J.D. (1996) Responses of group-housed neonatal chicks to posthatch holding environment. Transactions of the American Society of Agricultural Engineers, 39(6): 2249-2254.

Xin, H. & Lee, K. (1996) Use of aqua-Jel® and feed for nutrient supply during long journey air transport of baby chicks. Transactions of the American Society of Agricultural Engineers, 39(3): 1123-1126.

Xin, H. & Lee, K. (1997) Physiological evaluation of chick morbidity during extended post-hatch holding. Journal of Applied Poultry Science, 6: 417-421

Xin, H. (1997) Mortality and body weight of breeder chicks as influenced by air temperature fluctuations. Journal of Applied Poultry Research, 6(2): 199-204.

Xin, H., Rieger, S.R. (1995a) Environment and mortality associated with remote airtransport of day-old chicks. Proceedings of the American Society of Agricultural Engineers 1994 Winter Meeting Paper No. 944557

Xin, H., Rieger, S.R. (1995b) Physical conditions and mortalities associated with international transport of young chicks. Transaction of the ASAE 38: 1863-1867.

Xin, H., Sell, J.L. and Ahn, D.U. (1996) Effects of light and darkness on heat and moisture production of broilers. *Transactions of the American Agricultural Society* 39, 2255-2258

Xu H.T., (1996). The behaviour of rabbit. 6th World Rabbit Congress, Toulose, 2: 437-440.

Yerex D. and Spiers I., (1987). Modern deer farm management. Ampersand Publ. Ass. Ltd., New Zealand.

Zomborszky Z., Feher T., Horn E., Poteczin E., Tuboly S., and Kovacs-Zomborszky M., (1996). Comparison of some blood parameters of captured and farmed red deer (*Cervus elaphus*) hinds. Acta Veterinaria Ungarica, 44 (4): 433-441.

Zomborszky Z., Hafner J., and Feher T., (1993). Values of serum-cortisol-studies on the stress susceptibility and adaptation ability of red deer with intensive keeping. Magyar Allatorvosok Lapja Feb., 91-95.

Zulkifli, I. and Siegel, P.B. (1995). Is there a possitive side to stress? World Poultry Science Journal, 51, 63-76.

Zylla-Bluhm, B. (1993).Zu Abstammung, Herkunft Haltung, Verhalten und einige Verhaltensstörungen des Truthuhnes (*Meleagris gallopavo L*., 1758) –Eine bewertende Literaturübersicht -Inaugrual- Dissertation der Tierärztlichen Fakultät der Ludwig-Maximilians-Universität München 1993.

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