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The welfare of calves during handling and transport

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ABSTRACT

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Transport normally leads to poor welfare in calves and evidence from mortality rate, heart rate, adrenal activity, enzyme changes, immunological effects, carcass quality and behaviour shows that welfare can be very poor. Loading and unloading are usually the most stressful procedures but vehicle conditions and journey characteristics are also important. More information is needed concerning the practices and vehicles which lead to the least welfare problems. Previous experience affects responses to handling and transport; those calves reared in crates being particularly ill-equipped to cope with the procedures. Those people involved in handling and transport should have a financial incentive to treat animals well and there should be more effective policing of the procedures and vehicles during national and international journeys.

INTRODUCTION

A substantial trade involving transportation of calves (bovines of 6 months or less) exists throughout the European Community (E.C.), both within and between countries. If we consider the U.K., for example, every year thousands of 2–3-week-old calves are exported, mainly to Italy's veal units. Many surplus dairy or beef calves of 7 days of age onwards are transported to and from markets (possibly several times) and, in addition, many 1-week-old calves and 15–16-week-old veal calves are transported to slaughter. Still more calves are moved, at various ages, merely from one part of the farm to another. Nowadays, road transportation is by far the most common mode of transit, using articulated lorries which are able to board roll-on/roll-off ferries, or smaller vehicles and trailers where fewer animals are to be moved.

Research shows that handling and transport can be a severe stress for animals. It is important to ascertain just how poor calf welfare is during the various handling and transport procedures and whether or not some individuals are more susceptible to transit stress problems than others. The welfare of an animal has been defined as its state as regards its attempts to cope with its environment (Broom, 1986, 1988) and may be considered to vary along a continuum from good to poor. In order to monitor an animal's welfare, various indicators may be used including assessments of mortality, health status, growth, reproductive success, physiology and behaviour. For a review of welfare indicators, see Smidt (1983), Broom (1988) and Fraser and Broom (1990).

Handling and transport involve a complex mixture of adverse stimuli, which act on the animal to a greater or lesser extent depending on the conditions and the methods used. The individual components include: handling during loading and unloading, removal from familiar to unfamiliar conditions, mixing of unfamiliar animals often with crowding, fluctuating temperatures, deprivation of food and water, and sometimes, for very young calves, weaning. The disturbance for the animal is psychological as well as physical and physiological. Calf welfare during transit may be very poor.

Stress effects can be measured physiologically by studying neurochemical and neuroendocrinological reactions at brain level, or by monitoring signs of activation of either the sympathetic–adrenomedullary system which involves the instantaneous release of catecholamines such as adrenaline and noradrenaline, or the hypothalamic–pituitary–adrenocortical (HPA) system which involves the slower release of glucocorticoids, such as cortisol. The plasma concentrations of these hormones may be measured directly, or the various indirect changes produced by these hormones at the level of effector organs may be studied. When measuring parameters such as blood glucocorticoid concentrations, the contribution of endogenous variations in adrenal activity must be analysed before the effects of treatments can be studied, and the confounding effect of sampling must be taken into account.

Behaviour also provides useful information concerning animal welfare (Ödberg, 1987; Wiepkema, 1987). When the behaviour of an individual differs from that which is considered to be the norm for the population, it may indicate that all is not well. For instance, damaging behaviour, such as self-mutilation sometimes shown by monkeys kept in barren laboratory environments, is a clear sign of animal suffering. Stereotyped behaviours, such as bar-biting in sows and tongue-rolling in cattle, must be a sign of poor welfare and may be a mechanism used by the animal to cope with its environment. Much debate continues in the area of behavioural assessment of welfare (see Dawkins, 1988). For a detailed study of stress in farm animals, using both physiological and behavioural measures, see Wiepkema and van Adrichem (1987).

There are several useful reviews in the literature concerning transportation of cattle (e.g. Hails, 1978). For instance, Leach (1982) reviews the effects of transport on cattle physiology, Kenny and Tarrant (1982) look at the effects on behaviour, and Ewbank (1986) reviews the calf trade and legal protection of calves during transport. The aim of this review is to report the findings of those studies which have looked specifically at the responses of calves to handling and transport stress. These include those in which the journey from farm to destination has been considered in its entirety, and the few studies in which attempts have been made to assess the relative effects of the different stages: of handling during loading and unloading, regrouping of animals, confinement on the vehicle, and water and food deprivation. This is followed by a consideration of factors which may influence the response, including age at transport, journey duration, breed of calf and previous experience. Evident gaps in the literature are pinpointed and suggestions for further research are made.

RESPONSES OF CALVES TO BOTH HANDLING AND TRANSPORT

The following studies are those in which the responses of calves to transport taken as a collective stressor are considered, without attempting to break down the process into its different stages. Many responses to transport are short-term and measurements must be made during or immediately following the journey, for example a rapid decline to pre-transport levels occurs in many physiological parameters of stress.

Mortality

Transportation of calves has been shown to increase mortality rates over and above those of calves which are home-bred and not transported (Leech et al., 1968). In a study carried out by Staples and Haugse (1974), 60.3% of 1769 calves which were transported before 2 weeks of age, fell ill during the following 4 weeks, and 21.7% died. Indeed, calves, particularly those of a very young age and travelling over long distances, often die following transport (Barnes et al., 1975).

Heart rate responses

A rise in heart rate in response to sympathetic stimulation occurs during short-term stressful situations such as transport. For instance, Stephens and Toner (1974, 1975) transported 2–4-month-old calves for 1 h and found the average increase in heart rate to be from 80 beats per min (bpm) to 110–115 bpm. Thus, monitoring of heart rate provides a convenient measurement for determination of fearful conditions. The use of radio-telemetric devices has an advantage in that there need be no contact with handlers during measurement.

Blood biochemistry

An elevation in plasma cortisol levels in response to transport has been widely documented in the calf (Johnston and Buckland, 1976; Gwasdauskas et al., 1978; Crookshank et al., 1979; Kent and Ewbank, 1983, 1986a,b), indicating activation of the HPA axis. Kent (1977) found a rapid decline to pre-transport levels following unloading and concluded that blood samples should be taken during transit, if possible, in order to detect any increase in cortisol levels. A concomitant rise in saliva cortisol, representing the unbound plasma fraction, accompanying rising plasma cortisol levels has been found in a study involving 19 calves transported for 30 min of manoeuvres followed by 2 h of normal road transport (Fell and Shutt, 1986). A subsequent increase in urinary glucocorticoid breakdown products such as 11- and 17-hydroxycorticosterone also occurs (Rocco and Aguggini, 1972; Morisse, 1982, respectively).

Changes in blood cellular components accompany variations in blood hormones involved in the stress response and may be monitored as indirect changes brought about by the changes in hormone levels. For instance, Paape et al. (1974) suggested that glucocorticoids might decrease leucocyte infiltration into tissue, so decreasing circulating levels. Morisse (1982) studied the changes in blood components of 25 transported calves compared with 25 calves of the same age which were not transported (controls). The transported calves showed significant increases in thrombocyte and neutrophil counts compared with control calves, measured after the journey. Kent and Ewbank (1986a) found significant increases in neutrophil and lymphocyte numbers in two groups of 1- to 3-week-old calves transported for 6 or 18 h, and sampled during and after the journeys. In a study by Phillips (1984) involving beef calves transported over a distance of 400 km and confined in unfamiliar surroundings for 15 h, fibrinogen concentrations were found to be elevated in samples taken at the end of the journey when compared with basal levels. This has been shown to accompany stimulation of the hypothalamic–pituitary–adrenocortical axis.

Protein catabolism accompanies elevations in plasma glucocorticoids and explains the decrease in serum protein levels found following transport in cattle (Wöhler, 1971) and calves (Kent, 1977). Blood protein levels, therefore, provide another indirect measurement of the effects of stress. An increase in haematocrit following a journey has been noted (Kent, 1977) as a result of dehydration and the effects of adrenaline. Further, increases in various blood enzymes occur as a result of cell damage and leakage during stress. For instance, Groth and Gränzer (1975) measured a significant increase in several enzymes in calves weighing 107–165 kg and transported a distance of 266–310 km. Likewise, Agnes et al. (1972) and Deutschmann et al. (1976) found increases in several enzymes in transported cattle. Such findings are evidence of adverse effects of transport on calf welfare.

Immune system responses

Severe and acute stress has been shown to be an immunosuppressant (Kelley, 1980) and as a consequence of a less effective immune defence, an increased disease incidence has been observed in transported calves. For example, an increased occurrence of respiratory diseases (Dvorak, 1975), a condition commonly known as "shipping fever", has been found.

This reduction in immune competence has been investigated in various studies and results are equivocal. For instance, Hartmann et al. (1973a) found that transported calves showed a reduced ability to synthesise antibodies, though the immunoglobulin pool appeared unchanged. However, Simensen et al. (1980) did find that transportation of calves resulted in a significant but brief suppression of average serum immunoglobulins. In contrast, Mormède et al. (1982) did not find any changes in immunoglobulins immediately in response to transit, but levels decreased 1 week later, suggesting a longer-term response. Kelley et al. (1981) demonstrated that the blastogenic response of peripheral blood mononuclear cells to mitogenic stimulation by concanavalin A was lower in transported dairy calves than it was in the same calves 1 or 2 weeks later, suggesting a lowering of the immune response as a result of transit stress. Similar responses were found in response to the mitogen phytohaemagglutinin. There is scope here for more work to establish exactly how, and on what time-scale in relation to the action of the stressor, the calf immune system is affected by the acute stress of transport.

Carcass quality

A lowered average daily weight gain is apparent as a result of transit stress in some calves (Mormède et al., 1982). A further economic loss occurs in slaughter cattle as a result of damage to the integument and bruising during transit. This damage occurs because of the confined conditions during transport, accompanied by increased aggression because of the mixing of unfamiliar animals. The situation is exacerbated by inadequacies in vehicle design and lack of care during loading, unloading and driving of the vehicle. For instance, McCausland et al. (1977) found that in a study of 16 400 transported calves, 50% had bruised stifles, which the authors attribute to the transit. Also, T. Grandin (personal communication, 1981) reported that cattle which had been handled roughly during weighing and loading at a feed-lot had 15.5% bruising over their bodies, while cattle which had been walked onto the scales and trucks carefully and with the minimum of excitement, had only 8.35% bruising. Further, the highest percentage of bruising was located in the most valuable part of the animal – the loin area.

Besides the bruising and lesions which occur as a result of physical trauma, a problem of immense economic importance to the meat industry and to the farmer's pocket, is the incidence of dark, firm, dry (DFD) meat. This occurs as a direct result of conditions during the hours before slaughter, including stress during transit; see reviews by Hails (1978), Tarrant (1981) and Tarrant (1990, this issue). The condition arises if muscle glycogen reserves are depleted before death, for example, by prolonged social disturbance, so that little lactic acid can be produced in muscles after death, and the pH remains high. DFD meat is characterised by poor keeping quality, a dark purple-black colour, a high water-binding capacity and poor palatibility. If it were possible to detect DFD meat before slaughter, for example in a muscle biopsy sample, slaughter could be postponed until such time that the animal had returned to an undisturbed state. An increased understanding of cattle behaviour in order to determine psychologically stressful conditions, accompanied by refined physiological techniques of assessment of welfare during transit, will help prevent this problem. Clearly, increased economic returns go hand-in-hand with improved welfare.

Behavioural responses

To complement physiological studies, studies of behaviour on the lorry provide additional information concerning the welfare during transit of cattle (see Bisschop, 1961; Sutton et al., 1967; Kenny and Tarrant, 1982), and calves (Kent, 1977; Friend et al., 1981). Most observations to date, however, have been rather subjective, leaving plenty of scope for further research. Behaviour observation facilitates identification of stressors if the general pattern of behaviour which is considered to be the norm for that population is altered either during or after a stressor. Kent (1977) looked at in-transit lying and sleeping behaviour and found that transport decreased lying, ruminating and sleeping times during a journey more than the effects of penning and starving only. This suggested a decrease in comfort activities during transit. Ruminating, for example, is thought to occur only when the animal is in a relaxed state. In a quantitative study of cattle behaviour on the lorry, Kenny (1985) found that confinement itself, rather than the responses to motion, determined the orientation adopted by cattle on the lorry. The author suggests that inability to orient appropriately may adversely affect an animal's capacity to cope with the motion of the lorry. A combination of both behavioural and physiological indicators provides the most thorough approach for welfare assessment.

It can be seen from the above studies that transport has various effects on the calf, and the evidence suggests that many are adverse. The extent to which calves are able to cope with transport, and the extent of their suffering, are questions which must be answered if good welfare of calves in transit is to be ensured.

THE CONTRIBUTORY PROBLEMS DURING HANDLING AND TRANSPORT

A few studies have attempted to break down the sequence from farm to slaughter or other destination into its component parts in order to examine the effects on the calf of each stage. If the most stressful parts of the process are highlighted, suggestions for improved methods may be made, or a different approach to particular stages of the process may be taken, in order to improve welfare.

Loading and unloading

Loading and unloading are considered by some workers to be the most stressful stages of transport (Hartmann et al., 1973b; Tennessen et al., 1984), because of the physical exertion required, the noise, and the effects of contact with people during handling. A sharp rise in cortisol levels in calves has been found during the first 2 h of transport (Kent and Ewbank, 1983) while levels tend to stabilise during long journeys, suggesting that the response may be due mainly to loading.

Modern management procedures do not lend themselves to familiarisation of animals with humans, consequently, the slightest contact with humans can initiate a substantial fear response. For instance, Stephens and Toner (1974) recorded the resting heart rate of a calf standing alone in a loose box to be 90–95 bpm. When held still by hand, the calf's heart rate rose to 145 bpm. Shutt and Fell (1990) showed that there was a rise in plasma β-endorphin when Hereford steers were handled. β-endorphin, an opiate peptide, is released by the pituitary along with other peptide hormones in response to both acute and chronic stress. Such physiological responses suggest that handling is stressful and so loading may be a particular problem. Boissy and Bouissou (1988) showed that prolonged handling had some effects on lessening the fear responses of calves to humans, and Crookshank et al. (1979) showed that elevations in cortisol levels decreased in transported calves as calves became accustomed to handling. It may, therefore, be prudent to familiarise stock with human handlers on a regular basis as a precautionary measure against handling stress.

Grandin has carried out work on design of cattle races to facilitate loading, with the behaviour of cattle in mind (Grandin, 1980a,b). It has been found that calves which are handled in a well-designed facility have slower heart rates than calves handled roughly in a poorly planned pen (T. Grandin, personal communication, 1984).

Introduction to a novel environment

Transport inevitably involves introducing the calf to a new environment, which imposes a psychological stress. Work by Kondo and Hurnick (1988) showed that when cows were moved from a familiar stall to an unfamiliar one, heart rate increased from an average of 83 bpm to 107 bpm. This was accompanied by an increase in agonistic behaviour and some increase in the catecholamines, nonadrenaline and adrenaline. Kenny and Tarrant (1987) looked at the changes in behaviour in 15-month-old Friesian bulls during transport-related treatments including introduction of a familiar group to a new environment. They found an increase in the frequency of numerous social behaviours including butts, threats and mounting, all of which may have adverse consequences on meat quality in the slaughter animal.

Social regrouping and confinement on the lorry

Another major stressor involved in transport is the social aspect of mixing unfamiliar animals in a confined space. Animals maintain an individual distance between themselves and congeners. If this personal space is intruded upon, a conflict situation arises which must be resolved, resulting in an increased frequency of aggressive encounters. During transport, intrusion into personal space is inevitable and this may lead to problems, particularly in groups of cattle unfamiliar with each other, where competitive interactions will occur in order to establish dominance. Kenny and Tarrant (1987) found that plasma cortisol concentrations in transported young bulls increased consistently as the complexity of transport treatment increased. That is, they found that when bulls were both regrouped and exposed to a new environment, the frequency of sexual activity, mock fighting and exploratory behaviour increased above observed resting values. In addition, plasma cortisol concentrations, the muscle enzyme creatine kinase plasma concentrations, and heart rate, significantly increased in response to social regrouping.

Stocking density and vehicle design

The stocking density on the vehicle is important in order that calves are neither squashed nor penned so loosely that they may be thrown about the vehicle during motion. German experts (cited in Commission of the European Communities (CEC), 1984) recommend that calves weighing less than 150 kg should be loaded at a stocking density of 0.33–0.7 m^2 per calf and that the group size should be <30 calves weighing 40–80 kg, and <25 calves weighing 80–150 kg. Livestock lorries are designed according to strict regulations concerning, for example, materials to be used, provision for adequate ventilation, and pen sizes, in order to safeguard the comfort and welfare of animals during transport. Some important findings have materialised from general studies of transport. For instance, transportation effects on heart rate and plasma cortisol were greater when a calf was free to move around during transport than when the same journey was repeated with a calf confined in a wooden cubicle (Stephens and Toner, 1975). Pregnant heifers which were transported loose in a compartment were found to lose significantly more weight compared with those which were penned during transport; but pens were found to increase the number of skin lesions on the hipbone (Lambooy and Hulsegge, 1988). However, much work needs to be done to investigate different vehicle designs and relate these to welfare of cattle during transport.

Water and food deprivation

Kent and Ewbank (1983, 1986a,b) using control calves starved for the same duration as that for calves undertaking a journey, found that some of the changes occurring during transport are a consequence of withdrawal of food. Friend et al. (1981) found that when calves were transported by rail in a car equipped with food and water, they experienced an average weight loss of 4.5%, compared with a 10% loss in calves transported by truck not equipped for feeding. This loss of weight found in transported calves (Groth and Gränzer, 1975; Crookshank et al., 1979) is a direct result of food and water deprivation, defaecation and excretory losses during the journey, which result in acute dehydration (Mormède et al., 1982).

Circulating glucocorticoids cause elevations in blood glucose levels (hyperglycaemia). However, findings have been equivocal because the feeding regimen before transport confounds results. If the calves are fed several hours before transport for instance, pre-transit samples may be high and blood glucose levels could decline during the course of the journey, resulting in a drop in the measured levels. If the calves are fed immediately prior to transport, pre-transport measurements of glucose will be relatively low until the glucose reaches the circulation and, depending on the length of the journey, elevated levels may be found post-transport as a result of feeding. Hypoglycaemia has been found in transported calves (Hartmann et al., 1973b; Dantzer, 1982; Mormède et al., 1982) as a result of an increased energy requirement during transport, fasting during transit and the restriction of food intake both before and after transport to avoid gastrointestinal disorders.

FACTORS AFFECTING THE RESPONSES OF CALVES TO TRANSPORT

A few studies have been carried out to look at factors influencing the responses of calves to transport.

Journey duration

Mormède et al. (1982) looked at the effects of length of journey on 4- to 32-day-old calves. They found that numerous physiological parameters were modified by transportation but not by journey duration. However, increased length of journey substantially increased the susceptibility to respiratory diseases. There is also some indication that the longer the journey, the greater the loss of weight in steers (Self and Gay, 1972; Tennessen et al., 1984). More research is required in this area in view of the great distances over which many calves are moved, particularly on journeys between countries.

Age at transport

Kent (1977) and Kent and Ewbank (1983, 1986a,b) looked at the effects of road transport on calves of differing ages and found, with a comprehensive study of blood chemistry and some behavioural observations during transit, that 1- to 3-week-old calves were affected least, followed by 3- to 4-month-old calves, while 6-month-old calves appeared most stressed by transport. Fell and Shutt (1986) also found evidence to suggest age effects in that younger calves showed less response to transport, measured by salivary cortisol. A confounding factor, which must be taken into account during these studies, is that many blood parameters such as serum cortisol levels, plasma 11-hydroxycorticosterone (Hartmann et al., 1973a) and immunoglobulin levels (Mormède et al., 1982) vary with age.

Such studies provide important information concerning responses of calves of different ages to transport and, in the light of such evidence, it may be possible to avoid transport at particularly susceptible ages.

Breed effects

It is well known that some breeds of cattle have a tendency to be more flighty than others and differences between breeds in basal hormonal levels, such as cortisol, have been found. In studies by Zavy et al. (1988) the authors found that the breed with the lowest basal cortisol levels showed a greater response to an adrenocorticotrophic hormone (ACTH) challenge than did other breeds with higher basal levels. There is also some evidence for breed differences in response to transport. Fell and Shutt (1988) found a tendency for Friesian calves < 1 month of age to have lower adrenocorticol responses to transport than crossbred calves of the same age. Also, Phillips et al. (1987) showed that some breeds had lower average daily gains following transport compared with other breeds.

Previous experience

Previous experience has been shown to determine how animals perceive and respond to an emotionally stressful situation (Reid and Mills, 1962; Phillips et al., 1982). Creel and Albright (1988) showed that when yearling heifers were exposed to a short-term stressor (30 min of rounding up, driving and haltering) those which had been reared in visual and tactile isolation had significantly higher mean cortisol concentrations than control calves reared in pens, suggesting that the isolates were more stressed than the penned calves. Thus, differences in response to the acute stress of transport are likely, depending on previous experience of the calves.

Many calves are reared in isolation in pens or crates, such as dairy calves which are often individually housed and deprived of all social contacts until weaning, and veal calves. In the E.C., 7 million out of a total of 22 million calves are reared per annum in veal crates (Susmel, 1987) and fed on a diet with inadequate iron and roughage. Various studies have been carried out to compare the welfare of calves reared in groups with that of calves reared in pens or crates (van Putten, 1982; Dantzer et al., 1983; Webster et al., 1985; de Wilt, 1986). Generally, isolation-reared calves are less active and have a less complete behavioural repertoire compared with group-reared calves. Various behaviours which are considered to be abnormal have been shown to develop in crate calves, such as oral sterotypies (Riese et al., 1977; Broom, 1983; Graf, 1984; Sambraus et al., 1984; de Wilt, 1985), for example, tongue-rolling, excessive chewing of the pen and excessive grooming, which may lead to the formation of hair-balls in the rumen.

There are also physiological differences between group and individually reared calves which show that welfare is poorer during close confinement. Mormède et al. (1983) showed that tied calves had higher basal blood cortisol levels than group calves at 3 weeks of age, after 1 week of differential housing. Because underlying differences are not always apparent in situ, it is useful to look at the responses to stimuli. After 6 weeks of differential housing, 160 male calves were subjected to ACTH challenge, and the adrenal cortex response was significantly greater in tethered calves compared with group calves.

Friend et al. (1985) found a gradation in several calf blood parameters ranging from the most restrictive stall, to pen, hutch, and the least restrictive yard housing. A parallel study of the behaviour of the calves showed that treatments differed by the degree of restraint and social isolation imposed (Dellmeier et al., 1985). Waterhouse (1978) found that when isolation-reared calves were mixed with other calves, they exhibited a drop in activity and much avoidance behaviour owing to lack of social experience. Furthermore, isolation-reared calves have been shown to come lower in the dominance order after mixing, than group-reared calves in studies by Donaldson (1970),

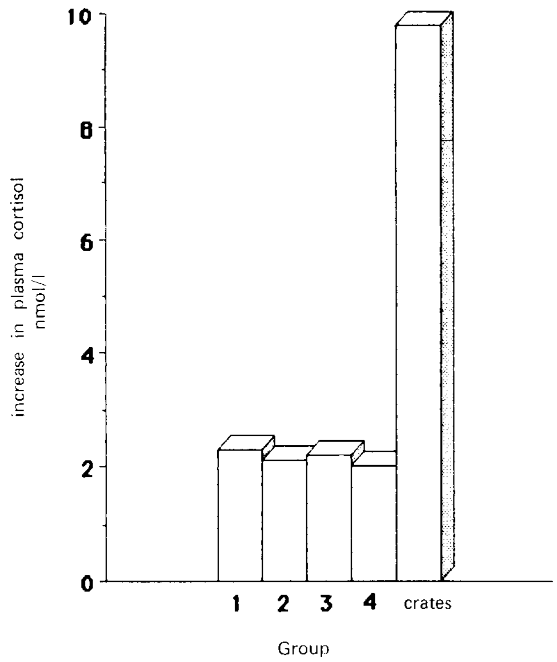

Fig. 1. Mean increase in blood cortisol levels as a result of handling and transport. Comparison of group-reared and crate-reared calves. Mean of crates significantly different from mean of all groups, $P<0.00005$.

Warnick et al. (1977), Broom and Leaver (1978), and Arave et al. (1985). Thus, mixing on the lorry during transport is likely to be a particular problem for individually reared calves.

In a recent study by the authors Trunkfield et al. (1990), the effects of differential housing experience on calf responses to the acute stress of transport are investigated. The aim of the work is to compare abilities to cope with handling and transport of veal calves reared for 6 months individually in crates or in groups. Calves reared in isolation had greater blood cortisol responses to handling and transport than did calves of the same age, reared in four groups of 13–15 individuals ($P<0.00005$), see Fig. 1. Isolates had more difficulty in walking and a significant increase in body temperature following transport. No rise in temperature was detected in group-reared calves. The greater response of isolates to transport stress is probably due in part, to the trauma of walking for the first time in 6 months, particularly when boarding the ramp to the lorry. Also, the stress of mixing with conspecifics in close confinement for the first time is likely to be considerable.

The experiment described above emphasises the importance of previous experience and physical condition on the responses of calves to transport. The calves housed in crates for 6 months had difficulties in walking and were generally ill-prepared for coping with loading and transport. If calves reared in close confinement are severely affected by handling and transport then this is further evidence suggesting that such housing methods should be discontinued.

CONCLUSIONS

Much evidence suggests that calves undergo considerable stress during transport. Behaviour is found to alter in that there is response to disturbing new situations, an increase in level of aggression as a result of confinement on the lorry, and reduced occurrence of comfort activities. Nevertheless, more quantitative behavioural work is necessary to complement physiological studies. Many physiological changes have been reported but there should be more attempts to decide to what extent these indicate poor welfare. However, there is evidence for the many physiological changes involved in the stress response occurring as a result of transport, including activation of both the sympathetic–adrenomedullary system and the hypothalamic–pituitary–adrenocortical system. Many workers have looked at cortisol as a stress indicator but this hormone has a short half-life and is subject to diurnal variations, breed differences and changes with age. There are also difficulties in interpretation because of feedback mechanisms which act to suppress cortisol output. Use must also be made of other indicators which are being used in many other areas of welfare research in order to determine a more complete blood profile of the response to transport.

It is evident that the different stages of transport may have different effects, although more work needs to be done to determine which aspects are the most stressful. For instance, it is a general problem when transporting animals, that individuals which have often had little close contact with man are suddenly forced into close contact during driving or other handling prior to loading. Previous handling appears to reduce adverse effects of handling which occurs prior to transport. The actions of the people involved in loading, allocating space, driving vehicles, and unloading can all have a considerable effect on welfare, and poor meat quality and carcass blemishes can be a consequence of rough handling or difficult journey conditions. Mixing of unfamiliar animals on the lorry exacerbates the problem and it is wise to prevent mixing of groups where possible. Economic returns and animal welfare are both improved if the staff concerned have a financial incentive to ensure that the animals are in good condition, or are penalised if this is not done. In designing good procedures for handling and transport a knowledge is required of social behaviour and of situations which are particularly disturbing to calves, as well as knowledge of the range of physical conditions necessary for calves. Vehicle design, race and loading ramp design, and procedures during loading or unloading all require improvement if poor welfare during transport is to be avoided.

The effect of transport on the immune system requires further study in order to clarify how the various immune responses are affected, and on what time-scale with respect to action of the stressor. Such information is important in terms of aetiology of disease as a result of transport. Furthermore, variations among animals in their response to transport have not been investigated thoroughly. Guidelines are needed which predict the individuals which are most likely to suffer as a result of transport, because of their breed, age, sex, behaviour, position in the hierarchy, or previous experience.

Policing of livestock haulage is difficult and farmers using their own vehicles are exempt from some of the regulations. Legislation applicable to calf transport is very general and, in the U.K., Codes of Recommendations laid down by The Ministry of Agriculture, Fisheries and Food are useful, but not obligatory, leaving plenty of room for negligence. Transit between countries presents a particularly difficult problem as the level of care when animals are changing hands is often poor. There should be more effective policing of the handling of animals and of conditions during national and international journeys. For a review of the pitfalls in the legislation governing transport of animals, see Muriel (1986). Because of the scale of the problem and the implications of freer travel throughout Europe in 1992/1993 it is necessary to tighten prosecution procedures and to enhance public awareness of the problem.

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