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The effect of sea transport from Ireland to the Lebanon on inflammatory, adrenocortical, metabolic and behavioural responses of bulls

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ABSTRACT

The objective was to investigate the effect of sea transport on the physiological, behavioural and performance responses of bulls. One-hundred and eleven bulls (mean body weight (standard error of the mean) 429 (5.7 kg)) were randomly assigned to one of three treatments; control (C; $n = 54$) bulls were housed in 6 pens at Teagasc, Grange Research Centre at a stocking density of (1), 1.7 m^2/head (C1.7; 3 pens) and (2), 3.4 m^2/head (C3.4; 3 pens) and (3), transported (T) bulls ($n = 57$) were penned at a space allowance of 1.7 m^2/head (6 pens) and allocated to one of five decks on the shipping vessel. C and T bulls were subjected to the same live weight (d −2), blood sampling and rectal temperature (d −1) measurements pre-transport and on d 3, d 6, d 9 and d 11 of the study. T bulls had greater ($P < 0.05$) live weight gain (+4.4%) compared with C1.7 bulls (−2.0%) and C3.4 (+0.13%)). Time spent lying was greater ($P < 0.05$) among C1.7 and C3.4 bulls (9.9% and 53.3%, respectively) compared with T bulls (45.8%). Rectal body temperature was not different ($P > 0.05$) among treatment groups throughout the study. At d 11, neutrophil % was greater ($P < 0.05$) in transported bulls on decks 1, 2, 4 and 5 compared with C1.7 and C3.4 treatments. Plasma cortisol concentrations were not different ($P > 0.05$) between control and transported bulls. Plasma creatine kinase (CK) activity was lower ($P < 0.05$) among C3.4 and T bulls on decks 2, 3, 4 and 5 compared with d 3 values. In conclusion, the welfare of bulls transported by sea on the sea journey was not adversely affected. Housing control bulls at a reduced space allowance (1.7 m^2) had a negative effect on live weight gain.

1. Introduction

There is a paucity of literature examining the effect of transportation by sea using a walk-on walk-off shipping vessel on performance, physiological, immunological and behavioural responses of bulls, particularly over an extended period of 11 days. Some transport studies by road, reviewed by Knowles (1999), reported that cattle became increasingly dehydrated, suffered increased protein dehydration, some depletion in muscle glycogen and animals demonstrated more lying in the latter stages of the journey (Knowles et al., 1999). Tarrant et al. (1992) concluded that road journeys longer than 24 h would be detrimental to animal welfare. Warriss et al. (1995) transported 350 kg cattle for 15 h, and reported that the effects were little different from the effects of 10 h of transport., the authors concluded that 15 h of transport was acceptable from the point of view of animal transport. Previous road transport studies, up to 24 h transport, of cattle reported that animal welfare was compromised due to feed and water deprivation, thermal and environmental stress and physical exhaustion (Tarrant, 1990; Tarrant et al., 1992; Knowles, 1999). A previous study concerned the physiological, haematological and immunological responses of 9-month old bulls (250 kg) to transport at two stocking densities (0.85 and 1.27 m^2/250 kg animal) on a 12-h journey by road. It was concluded that, within the conditions of the study, there were no significant biological effects of transporting bulls at a space allowance of 1.27 m^2/animal compared with a spatial allowance of 0.85 m^2 on a 12 h road journey (Earley and O'Riordan, 2006; Earley et al., 2006). Sea transport studies from Australia to the Middle-East have reported that the main causes of cattle deaths were heat stroke, trauma and respiratory disease (Norris et al., 2003; Norris, 2005). With cattle standing for long periods of time during transportation, one would assume that motion and vibration levels do impact on their welfare. In pig studies, it has been shown that vibration and random motion may induce nausea, discomfort, fatigue and distress (Bradshaw et al., 1996a,b,c).

The objective of the study was to investigate the effect of transport by sea on performance, physiological, immunological and behavioural responses of bulls over a 12-day sea journey. In addition, the effect of vibration levels and environmental conditions

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were monitored. The study hypothesis was that transport of cattle by sea using a walk-on walk-off shipping vessel is not detrimental to their welfare. To test this hypothesis, physiological markers of stress (cortisol), immunity (phytohaemagglutin A (PHA)-induced interferon-γ production) the acute acute phase protein (haptoglobin) and haematological profiles, were investigated. In relation to fear, arousal and physical activity, physiological markers of energy metabolism (β hydroxy butyrate (βHB), albumin, protein, glucose, non-esterified fatty acid (NEFA) and urea) and muscle activity (creatine kinase (CK) activity) before and during transport were measured. In addition, behaviour, live weight, and rectal temperature were monitored.

2. Materials and methods

2.1. Animals and treatment

All animal procedures used in this study were conducted under an experimental license from the Irish Department of Health and Children in accordance with the Cruelty to Animals Act 1876 and the European Communities (Amendment of Cruelty to Animals Act 1876) Regulation 2002 and 2005.

One-hundred and eleven (mean live weight 429 (±SEM) 5.7 kg) bulls were sourced from farms and transported by road to a lairage at the shipping port on d −2 of the study. The pens in the lairage were bedded with a deep bed of cereal straw and animals had *ad libitum* access to a hay diet, with drinking water freely available through nipple drinkers. On day −1, the 111 bulls that were assembled in the lairage were assigned by live weight and farm of origin on d −1 to one of three treatments, control (1), housed at 1.7 m^2/head (C1.7), control (2), housed at 3.4 m^2/head (C3.4) and (3), transported (T) by ship (decks 1–5; at a space allowance of 1.7 m^2/animal) (Table 1). On day 0, C bulls ($n = 54$) were transported by road to an animal housing facility at Teagasc, Grange Research Centre and housed in 6 pens which were bedded with a deep bed of cereal straw. Each pen housed 9 animals at a spatial allowance of either 1.7 m^2/head (number of pens = 3) or 3.4 m^2/head (number of pens = 3). Similarly, on d 0, T bulls ($n = 57$) were transported by road to the ferry port and were penned in 6 pens on the shipping vessel at 14:00 GMT. The pens on the shipping vessel were bedded with a deep bed of cereal straw at a spatial allowance of 1.7 m^2/head on either forced (decks 1–3) or naturally ventilated decks (decks 4 and 5) (Table 1).

Control and transported bulls were subjected to the same sampling schedules (08:00 GMT) for blood sample collection, live weight recordings and rectal temperature measurements on d −1, 3, 6, 9 and 11 of the study. The C1.7, C3.4 T bulls were fed from the same feed sources and had *ad libitum* access to hay, straw and water. The C1.7, C3.4 T bulls were offered concentrate feed at a rate of 2 kg/head daily. A total of 1500 bulls were transported on the shipping vessel from Ireland to the Lebanon and the total journey duration by sea was 12 days.

2.2. Environmental conditions

All five decks on the shipping vessel and the pens in the control shed (Teagasc, Grange Beef Research Centre) were fitted with sensors for measuring mean daily temperature (°C), relative humidity (RH; %) which were automatically calculated by the device. The mean daily ambient air temperatures (°C) outside the control shed and on the outside of the ship were continuously recorded using Testo 175 data loggers (Eurolec, Ireland). In addition to these measurements, carbon dioxide (CO_2; ppm), hydrogen sulphide (H_2S; ppm), ammonia (NH_3; ppm), air velocity (m/s) and vapour density (td °C) were continuously on the ship using Testo 175 and Testo 445 data-loggers (Eurolec, Ireland). Tri-axial accelerometers (PCB Piezotronics, Inc., Environmental measurements, Ireland) were mounted on each deck of the shipping vessel to measure vibration and motion during the sea journey.

2.3. Live weight

The live weight of the bulls was recorded pre-transport (d −1). Animals were subsequently weighed on d 3, 6, 9 and 11 of the study. The C1.7, C3.4 and T bulls (decks 1–5) were weighed using identical precision weighing platform scales (Model SR3000, O'Donovan Engineering Co. Ltd., Cork, Ireland).

2.4. The rectal body temperature

The rectal body temperature was monitored before transportation (d −1) and on d 3, 6, 9 and 11 of the study using a digital thermometer (Jorgen Kruuse A/S; Model VT-801 BWC Lot No. 0701, Marslev, Denmark).

2.5. Behavioural observations

Behavioural observations were conducted throughout the study using CCTV cameras with infrared lighting for night vision. Each camera was positioned at an angle in front of the individual pens. The cameras were connected to a video tape recorder via a multi-vision system (Robot, monochrome duplex multiplexer) and recorded the behaviour on a 24 h basis throughout the study. The bulls were observed by instantaneous scan sampling at 10 min intervals (Altmann, 1974; Martin and Bateson, 1993) for standing, lying, eating and drinking behaviour. Social interactions such as licking and grooming and antagonistic behaviour, mainly, butting and mounting were also recorded. A count of the total number of occurrences of each behaviour was made for each scan time point. The percentage time values were calculated from the total count data for each behaviour. As the animals were subjected to continuous recordings, the count data was expressed as percentage time.

Table 1
Experimental groups of animals showing the number of bulls assigned to and space allowance (m^2) for control (C) and transport (T) treatments.

Pen assignments						
Treatment	Housing conditions for control (C) bulls at a space allowance of either 1.7 m^2 (C1.7) or 3.4 m^2 (C3.4).					
Control bulls (C) Number (n) of bulls per pen	C1.7 $n = 9$	C1.7 $n = 9$	C1.7 $n = 9$	C3.4 $n = 9$	C3.4 $n = 9$	C3.4 $n = 9$
Shipping vessel						
	Deck 1	Deck 2	Deck 3	Deck 4	Deck 5	Deck 5
	Forced ventilation			Natural ventilation		
Transported (T) bulls Number (n) of bulls per pen	1.7 m^2 $n = 11$	1.7 m^2 $n = 10$	1.7 m^2 $n = 10$	1.7 m^2 $n = 8$	1.7 m^2 $n = 9$	1.7 m^2 $n = 9$