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The effects of air transport on the behaviour and heart rate of horses

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Abstract

Although many horses (*Equus caballus*) travel by air, there is little information on the effect of this type of transport on their physiology and behaviour. This study monitored the behaviour and heart rate of horses during air transport to identify events that might be stressful, and to compare these measures across long and short haul air journeys. Body temperatures prior to and after transport were also measured. Heart rate was recorded before road transport to the airport to obtain resting levels, and recordings continued throughout subsequent road and air journeys. A range of social activities, together with body postures associated with balancing and resting, were recorded over a series of 30 min observation periods during the air journey. The air temperature and relative humidity (RH) in the aircraft were also recorded. During short haul flights (3–4 h), 16 horses were sampled. Heart rates were significantly higher ($P < 0.05$) during transitional events (i.e. while loading and unloading the truck and aircraft, and during ascent and descent) than when horses were resting or when the aircraft was in flight. In level flight, horses' heart rates were close to resting levels and they would regularly doze and rest. In comparison, during ascent and descent, social behaviour, including aggression and submission, increased, and horses were seen to regularly change body postures to maintain balance. During long haul flights (10–15 h), 19 horses were sampled. The difference in journey length did not change how horses responded to transport events. Air temperature and humidity were highest when the plane was stationary (e.g. during loading, unloading, refuelling and delays). Although some sharp increases in heart rate and activities suggested agitation during transitional stages of air transport, these events did not appear to be frequent or long enough to be a significant welfare concern. Horses appear to adapt well to air travel under the conditions studied.

Keywords: Horses; Air transportation; Welfare; Heart rate; Behaviour; Body temperature

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1. Introduction

The growth in international equestrian competitions in recent years has led to an increase in the number of horses being transported by air. Guidelines exist for transporting horses by air (e.g. the International Air Transport Association (IATA, 1998), Live Animals Regulations (LAR)), which specify container requirements and precautionary measures to be taken during loading and air transport. Such guidelines represent accepted best practice, but are not based on scientific studies. Within the industry, it is commonly thought that horses travel well by air. However, there is little research examining how horses cope under these conditions.

Most research on the effects of transport on horses has focused on road transport, where horses tend to display higher heart rates in a moving vehicle than in a stationary vehicle (Smith et al., 1994; Waran and Cuddeford, 1995). Waran and Cuddeford (1995) suggested that horses adopt certain body postures during road transport (forelegs forward and apart and hindlegs apart), in order to brace themselves to maintain balance. Both Smith et al. (1994) and Waran et al. (1996) reported that although heart rates decreased significantly over the road journey, they did not return to resting levels. Other studies have shown that horses travelling facing backwards during road transport have lower heart rates and are able to balance better than when they are facing forward (e.g. Clark et al., 1993; Cregier, 1982; Waran et al., 1996).

Increasing the length of a road journey can increase a horse's body temperature (Friend et al., 1998), weight loss (Foss and Lindner, 1996; Mars et al., 1992), level of dehydration (Van den Berg et al., 1998) and white blood cell count (Yamauchi et al., 1993). Similarly, Oikawa and Kusunose (1995) found that as the length of the road journey increased, the risk of horses developing equine respiratory disease (shipping fever) also increased. The normal rectal body temperature for a horse is 38.0 °C (Snow and Vogel, 1987). Oikawa et al. (1995) found that horses' body temperatures were as high as 39.9 °C following a 41 h road journey. An increase in body temperature is one indication that horses are dehydrated (Friend et al., 1998) and it is also one of the signs of respiratory disease (Leadon, 1994). None of these transport studies examined the effects of journey length on the behaviour of horses.

There are few studies of the effect of air transportation on horses. Leadon et al. (1990) monitored the health of horses during a 39 h flight and found that seven of the 112 horses developed shipping fever 1–2 days after transport, possibly due to the environmental conditions experienced during the flight (Leadon et al., 1990). Thornton (2000) provided a description of changes in heart rate of nine horses during air transport in a climate controlled, insect-proof container. He found that heart rates were 35–55 beats per min during the flight, but increased to 80–100 beats per min during take off and landing or when the horses were restrained for blood collection; however, there were no changes in haematological or blood biochemical values that suggested any detrimental effects. Marlin et al. (2001) studied six horses undergoing acclimatisation to a hot environment following a 9 h air journey. Following the flight, white blood cell counts were elevated and the horses were dehydrated, losing 4.1 ± 0.8% of their body weight, and taking 7 days to recover their pre-transport body weight.

Past studies of the effects of air transport have concentrated on heart rate and other physiological changes, rather than on behaviour. Measured together, behaviour and heart rate provide a good indication of an animal's reactions to social and environmental stressors (Baldock and Sibly, 1990). Aggressiveness and vocal behaviour may signal distress, and increase when animals are exposed to certain environmental stressors (e.g. McCall et al., 1985; Scheepens et al., 1991). The behaviour of horses travelling by air, and the effects of journey length on behaviour and stress responses have never been documented.

We monitored and quantified the behaviour, balancing postures and heart rates of horses during air transport procedures, to identify which aspects, if any, were most challenging. Responses measured during short haul flights were compared to those measured on long haul flights to determine the effects of journey length. The body temperature of horses, along with the air temperature and relative humidity (RH) during flights, were also recorded.

2. Materials and methods

2.1. Short haul flights

2.1.1. Animals

Horses destined for international travel were selected for observations on the basis that their owners agreed to their participation in the study. Sixteen horses ($\bar{x} = 5$; range 2–9 years) were observed during seven flights. Three were Thoroughbreds and 13 were Standardbreds (seven mares, seven geldings, and two stallions). The heart rates of 15 horses and the behaviour of 13 of these were successfully recorded (with one to three focal horses per flight). In total, there were 10–20 horses on each flight. All horses had considerable experience travelling by road and all, except one Standardbred gelding, had no previous experience of travelling by air.

2.1.2. Transport procedures

The observations and recordings took place during both road and subsequent air transport. A Nissan diesel truck with side ramps was used to transport the horses to the airport. The horsebox consisted of three compartments. Each compartment was designed so that three horses, separated by partitions, stood either diagonally or facing the direction of travel. The length of the road journey to the airport varied for each flight ($\bar{x} = 82$ min; range 50–147 min). All truck journeys covered a wide variety of roads, including winding country roads and motorways. Horses were transported to a compound at the Auckland International Airport, New Zealand, where they stayed on the trucks until the aircraft was ready for loading ($\bar{x} = 40$ min; range 20–58 min). The horses were then transported onto the tarmac and unloaded beside the aircraft, three at a time, and given a brief veterinary inspection. Prior to loading on to the aircraft, the horses were led up a ramp and loaded into open stalls one at a time with partitions placed between them. The stalls were moved onto pallets and lifted up and into the plane by a hydraulic lift; stalls were then rolled along the floor of the aircraft and locked into position. The average period of time to load the aircraft, measured from the time the stall was first moved onto the pallet, was 5 min (range 4–7 min). The Boeing 727, used for shipping cargo and horses, is a narrow-bodied aircraft that carries 12 freight pallets. Horses occupied open-topped stalls measuring 2.8 m × 1.8 m × 1.4 m high. Each stall could accommodate three large horses (or four small horses), separated by partitions, positioned longitudinally to the aircraft. Stalls were designed to meet IATA standards, and were equipped with disposable, non-slip flooring, and ropes that extended from the floor, to restrain the horses by their head collars. No provisions for watering or feeding the horses were available onboard the aircraft. All flights were approximately 3–4 h, cruising at an altitude of 31,000–33,000 ft with the cargo area pressurised to an altitude equivalent to 7000–8000 ft. Once the plane was stationary after landing, the main door was opened, and after approximately 10 min the horses were unloaded from the aircraft in the stalls via a hydraulic lift, which took 2–3 min. The stalls were then moved onto trolleys, which transported the horses across the tarmac to a compound at the airport (either Sydney or Melbourne International Airport, Australia).

2.1.3. Measurements

2.1.3.1. Heart rate. Polar Sport Tester™ PE3000 (Polar Electronics, Kempele, Finland) monitors, connected to two surface electrodes (90 mm × 28 mm), were used to collect a continuous record of heart rate for each horse. Ultrasound transmission gel was applied liberally to the horse's coat at each electrode contact point, one behind the scapula (approximately 5 cm ventral to the withers) and the other on the left thoracic wall, behind the point of the elbow. The electrodes were held in place by an elastic girth strap, looped around the horse's middle. The monitor was covered by an aluminium casing (65 mm × 115 mm × 25 mm deep) and carried in a canvas backpack, which was threaded through the elastic girth strap and positioned behind the wither. Heart rate monitors were fitted and recordings began while the selected horses were at rest in their stables (to establish baseline measures from which any changes in heart rate associated with the transport procedure could be gauged). The horses were left undisturbed until the truck arrived to transport them to the airport.

Recordings ended when the horses had been unloaded from the stalls at the airport compound. Recordings were downloaded into an IBM-compatible computer via a Polar Interface Plus™ (Polar Electronics, Kempele, Finland).

2.1.3.2. Behaviour. Observations began as the aircraft started to taxi across the tarmac (just before take off) and ended after landing when the plane was finally stationary. The same observer recorded behaviour during each flight, sitting approximately 2 m in front of the horses. Observer effects were considered to be minimal, because all the horses were very familiar with humans. Furthermore, horses are watched over by a groom during flights as part of the normal transport procedure. The activities observed were based on those previously recorded during road transport studies (e.g. Waran and Cuddeford, 1995) and were organised into six main categories (Table 1). Balancing postures were divided into two categories, because some movements, such as hitting the sides of the stall and swaying, were due to the movement of the plane, whereas others, such as resting their rumps, were deliberate movements made by the horses to enable them to remain upright (Table 1). Activities were recorded by using a series of 2 min continuous samples performed in sequence between two or three horses within four 30 min recording periods. The first

Table 1
Events recorded during 30 min samples from take off to landing

Social behaviour	
Non-agonistic	investigative and grooming behaviour directed towards another horse
Aggressive	ears positioned back while interacting and/or biting or attempting to bite another horse
Submissive	turning head away from a neighbouring horse in response to or to avoid being bitten
Vocalise	neighs, whinnys, snorts and squeals
Balancing postures	
Intentional	
Regaining balance	the horse moves its feet to remain upright after a momentary loss of stability
Shift weight	shift of body weight from one side to the other
Rump rest	pressing the rump against the back wall of the stall
Unintentional	
Sway	whole body rocks from side to side without shifting the feet
Hit	sudden contact of the body against either the walls of the stall or the partitions
Foot movements	
Kick	raising a hindleg and thrusting it backwards causing the hoof to strike the stall wall
Paw	raising a front leg and dragging it forwards and backwards across the floor
Stamp	raising a front leg and thrusting it downwards onto the floor
Relaxed behaviour	
Doze	head relaxed downward with eyes half closed
Lean	resting any part of the body against a side partition
Jaw movements (long haul flights only)	
Eat	grasping food followed by jaw movements and swallowing
Chew	jaw movements and swallowing in the absence of food
Head tilt	chewing with head tilted to one side; often accompanied by yawning
Hindleg position	
Normal	both hooves positioned square on the floor
Resting	one leg lifted with only the toe of the hoof in contact with the floor

30 min sample was obtained during ascent and included take off, the second one started half-an-hour after the end of the first observation period, the third started an hour after the end of the second observation period, and the fourth included descent and landing. During the first 2 min, the horse to the left of the observer was monitored, then in the next 2 min the horse in the middle was monitored, followed by the horse on the observer's right. This process was repeated until the 30 min recording period was completed. During each 2 min sample, the occurrence of each behaviour or event was recorded. At the end of every 2 min sample, the proportion of the 2 min spent standing normally or resting a hindleg was estimated (most frequently this was either 1.0 or 0.0). During the period in which the plane took off and during the very final stage of landing, observations cycled round all horses as quickly as possible. Once in the air or on the ground the 2 min cycle resumed.

2.1.3.3. Environmental conditions. Escort Junior v1.00 Multitrip Loggers (Tech Innovators, Auckland, New Zealand) were used to monitor the air temperature and RH in the aircraft during each flight. Temperature and RH loggers were placed on the sides of each horse stall. Each logger was programmed to record the air temperature and RH, at 30 min intervals, from the initial take off to the final landing. Once recordings were complete, the loggers were removed and the data was downloaded into an IBM-compatible computer via an interface.

2.2. Long haul flights

2.2.1. Animals

The procedure for selecting horses was the same as for the short haul study. Nineteen horses ($\bar{x} = 5$; range 11 months to 11 years) were observed on four flights. There were eight Thoroughbreds, 10 Thoroughbred cross breeds and one Arab (four mares, 13 geldings and two colts). Heart rate was successfully recorded for 18 horses and the behaviour of 10 of these were also recorded. All horses had considerable experience travelling by road, except for the 11-month-old Arab colt and a 4-year-old Thoroughbred cross. None of the horses had previously travelled by air.

2.2.2. Transport procedures

The observations and recordings took place during pre-flight road transport and subsequent air transport. The truck used to transport the horses to the airport was the same as that used in the short haul study. The aircraft were designed to carry cargo and livestock. On two flights, the aircraft was a stretched DC-8 freighter—a narrow-bodied aircraft that carries 18 pallets and has a very similar interior to the 727 described for the short haul study. Horses occupied open-topped stalls in this aircraft. On the other two flights, the aircraft was a Boeing 747 freighter and horses occupied closed stalls (i.e. entirely enclosed with a roof and a side door for access), measuring 2.2 m × 3.0 m (including 0.8 m for the groom's compartment) × 2.1 m high; the three horses in each stall were separated by partitions. When closed stalls were used, horses were unloaded from trucks and loaded into the stalls at the compound and then transported on trolleys across the tarmac to the aircraft, instead of being unloaded from the trucks beside the aircraft. Stalls were equipped with disposable, non-slip flooring covered with a thin layer of wood shavings. Horses were tied to the partitions by a rope attached to their head collars.

The duration of the first sector of three of the flights (Auckland to Los Angeles) was approximately 8 h; this was followed by a 1–2 h stopover for refuelling, and then a second sector approximately 5 h long. On the fourth flight (from Auckland to Singapore), the flight duration was 10 h. The cruising altitude for all flights was approximately 36,000 ft. Other differences to the procedure described in the short haul study were: the average travelling time for the road journey to the airport was 152 min (range 84–213 min); the average period of time that the horses had to wait at the airport compound before loading was 142 min; and horses were given access to hay ad libitum and water every 4–5 h during flights.

2.2.3. Measurements

The heart rate monitors and the air temperature and RH loggers were identical to those used in the short haul study; the recording of heart rate and behaviour, air temperature and

RH was also identical, except that recordings were over a longer period of time. On the Auckland to Los Angeles flights, heart rate recordings continued after the horses were unloaded at their final destination and ended after they were transported to quarantine. On the Auckland to Singapore flight, heart rate recordings ended after the horses were unloaded from the aircraft and were transported across the tarmac and unloaded from the stalls. On the Auckland to Los Angeles flights, rectal body temperature was measured using a digital thermometer. The first reading was made in the stables prior to transport. The second reading was obtained when the horses arrived at quarantine at the end of the journey. The last two readings were taken approximately 8 and 16 h post-transport.

2.3. Statistical analysis

Mean peak heart rates, during resting, loading and unloading the truck, loading and unloading the stalls and the aircraft, and during the actual take off, over the whole of transit and during actual landing during each flight for each horse were calculated. The number of observations of each behaviour and body posture (Table 1) were counted and the mean values for each flight were calculated. These were combined to give totals for each of the six categories shown in Table 1 for each flight. Repeated-measures analysis of variances (ANOVA) were used to determine if heart rates and behaviour differed between the different transport stages. Some of the data sets showed significant sphericity according to Mauchly's test. In these cases, the degrees of freedom were adjusted using the Huynd–Feldt correction. Pairwise comparisons of mean peak heart rates were also performed, using SPSS/PC (version 9.0, Microsoft Corp.).

For the long haul study, repeated-measures ANOVA were again used to determine if heart rates and behaviour differed between the first and second sectors of the flights. Pairwise comparisons of the means were performed using SPSS/PC (Microsoft Corp.). Student's *t*-test for independent samples were used to compare heart rate for the short and long haul flights, and to compare the behaviour observed over the last transit and final landing of the short and long haul flights. The Bonferroni correction was applied to the level of significance to account for the number of comparisons (Aron and Aron, 1999).

3. Results

3.1. Short haul flights

3.1.1. Heart rate

The average resting heart rate before transport (±S.E.) was 30 beats per min (±1) with a range of 25–35 beats per min over all horses ($n = 15$). Fig. 1 shows typical examples of the heart rate changes on two short haul flights (a) and (b), from the time the horses were loaded onto the truck until they arrived at their final destination. For all horses, heart rate increased from resting levels during loading onto the truck. For most horses, however, heart rates generally then decreased over the course of the road journey (Fig. 1a). For some

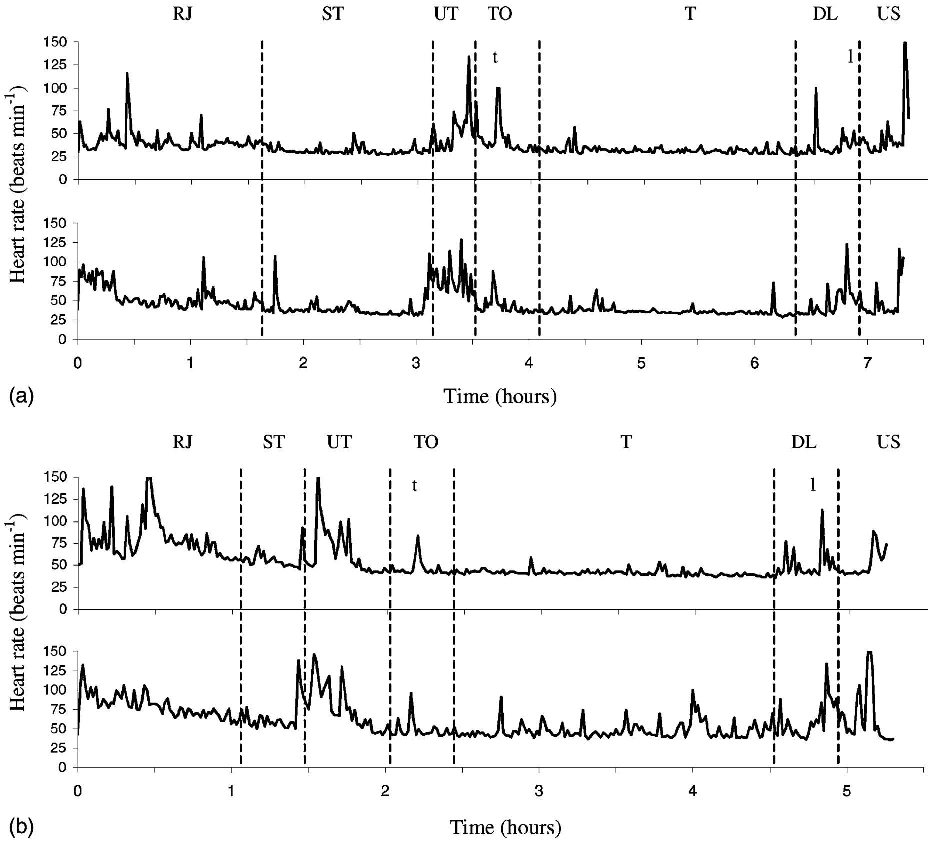

Fig. 1. Records of heart rate on flights from (a) Auckland to Melbourne and (b) Auckland to Sydney, for two horses on each flight. RJ, road journey; ST, stationary truck; UT, unloading truck and loading onto aircraft; TO, take off and ascent (t, moment of take off); T, transit; DL, descent and landing (l, moment of landing); US, unloading aircraft onto tarmac and unloading stalls.

horses, heart rates fluctuated throughout the road journey (Fig. 1b). The overall mean heart rate during road transport was 9 beats per min higher than that when the truck was stationary at the airport compound, before loading onto the plane. Heart rate increased when the horses were unloaded from the truck, loaded into the stalls and loaded into the aircraft on the hydraulic lift (Fig. 1).

After loading, the heart rate of most horses decreased while the aircraft remained stationary, preparing for take off (Fig. 1). During the take off, heart rates peaked briefly at the time the aircraft lifted off the ground and then decreased quite rapidly and stayed fairly constant throughout transit (Fig. 1). The greatest fluctuations over time were shown by the two horses whose data are shown in Fig. 1b. During transit, heart rates of all horses approached resting levels (average, 35 beats per min; range 28–48 beats per min). When the aircraft started to descend, most of the horses' heart rates increased and they tended to peak when the aircraft landed (Fig. 1). Heart rates then decreased as the

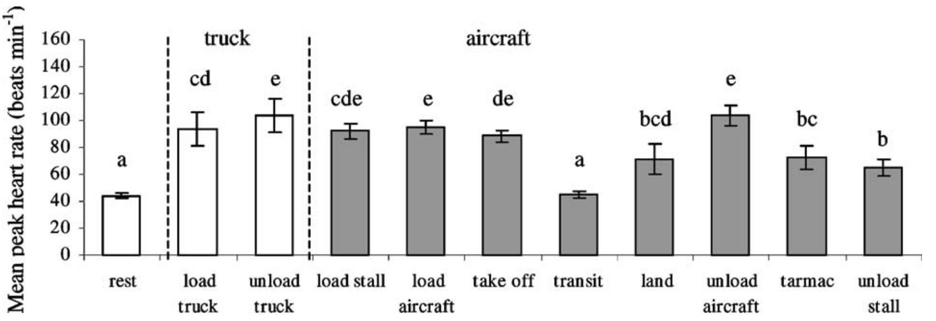

Fig. 2. Mean (±S.E.) peak heart rates at rest and during road transport procedures (white bars) and air transport procedures (grey bars).

aircraft taxied across the tarmac before unloading and there were high peaks associated with unloading the aircraft via the hydraulic lift and unloading the stalls onto the tarmac (Fig. 1).

The mean peak heart rates during resting, loading and unloading the truck, loading and unloading the stalls and the aircraft, and during take off, transit, landing and being towed across the tarmac are shown in Fig. 2. Lowest peak heart rates occurred during resting and air transit and highest during loading and unloading the truck and aircraft. Heart rates differed across events ($F(10, 90) = 11.28$, $P < 0.05$), but there were no significant differences across the flights ($F(4, 9) = 1.68$, not significant). In addition, the interaction between flights and events was not significant ($F(40, 90) = 0.91$, not significant).

3.1.2. Behaviour

Fig. 3 shows the mean frequency of each behavioural category (Table 1) over all seven short haul flights. All activities and body postures were more frequent during ascent and descent than during transit, except for relaxed behaviour. Horses relaxed more during transit than ascent and descent (Fig. 3). Intentional ($F(3, 15) = 25.5$, $P < 0.05$) and unintentional balancing postures ($F(3, 12) = 43.9$, $P < 0.05$) and social behaviour ($F(3, 15) = 3.5$, $P < 0.05$), were significantly higher, and relaxed behaviour ($F(3, 9) = 8.9$, $P < 0.05$) was significantly lower, during ascent and descent than during transit. The average proportion (±S.E.) of time spent resting a hindleg for the eight horses for which this was observed was 0.0 (±0.0), 0.5 (±0.1), 0.2 (±0.1), 0.0 (±0.0) during ascent, first and second transit and descent, respectively. Thus, during transit, horses tended to rest a hindleg and during ascent and descent horses stood with all four hooves positioned square on the floor.

3.1.3. Air temperature and relative humidity

Table 2 shows the mean air temperature and mean RH recorded in the main cargo hold during the six short haul flights. Both air temperature and RH were higher during stationary periods and when the horses were loading and unloading, and lower during transit. Both air temperature and RH were also higher during ascent and descent, compared to when the aircraft was in transit (Table 2).

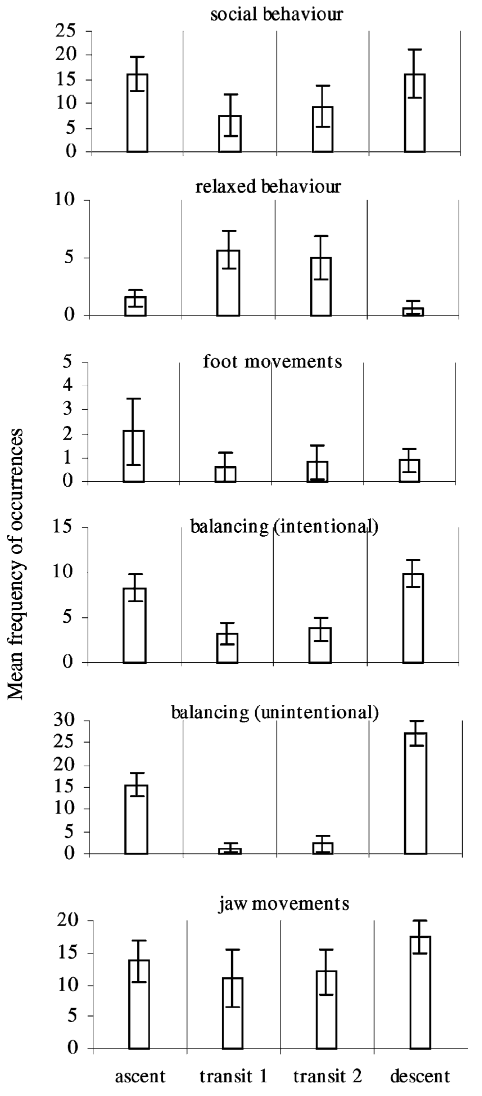

Fig. 3. Mean frequency (±S.E.) of each behaviour category during take off, ascent, transit 1 (1 h after take off), transit 2 (2 h after take off), descent and landing over seven short haul flights.

3.2. Long haul flights

3.2.1. Heart rate

Due to extensive delays on one flight, where the heart rate monitors exceeded their memory, complete heart rate data from two sectors were only available for eight horses on the remaining three flights (Fig. 4). Heart rates were low during resting and transit, and high during loading and unloading procedures (Fig. 4). Heart rates differed significantly across

Table 2
Mean air temperature (±S.E.) and mean RH (±S.E.) recorded in the cargo hold during the various periods of the short haul flights ($n = 6$)

Phase of flight	Mean air temperature (°C)	Mean RH (%)
Stationary	16.7 ± 1.0	90.0 ± 4.5
Ascent	16.6 ± 0.7	75.0 ± 8.0
Transit (1–1.5 h)	13.5 ± 0.8	52.5 ± 5.4
Transit (2–2.5 h)	13.4 ± 1.1	48.3 ± 5.37
Descent	15.4 ± 1.0	64.7 ± 8.2
Stationary	17.5 ± 0.9	85.8 ± 7.5

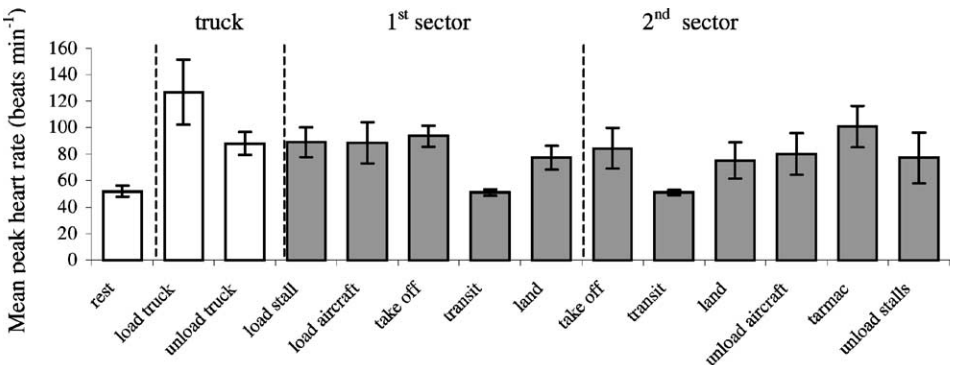

Fig. 4. Mean (±S.E.) peak heart rates at rest and during road transport procedures (white bars) and the first and second sector of the air transport procedure (grey bars).

events ($F(13, 65) = 3.48$, $P < 0.05$), but the interaction between events and flights was not significant ($F(26, 65) = 1.22$, not significant). There were also no significant differences between the flights ($F(2, 5) = 3.98$, not significant). There were no significant differences between the heart rates during transit in the first sector and second sector of the flights (Fig. 4).

3.2.2. Behaviour

Fig. 5 shows the mean frequency of each behaviour category over all long haul flights. In general, social activities, balancing postures, foot movements and jaw movements were more frequent during ascent and descent than during transit, as seen during short haul flights. The frequency of unintentional balancing postures ($F(6, 30) = 2.13$), jaw movements ($F(6, 30) = 0.44$), foot movements ($F(6, 30) = 1.47$) and social behaviour ($F(6, 24) = 1.61$) did not vary significantly during all six transit sampling periods, but intentional balancing postures ($F(6, 30) = 2.80$, $P < 0.05$) and relaxed behaviour did ($F(6, 30) = 2.50$, $P < 0.05$) (Fig. 5). Pairwise comparisons of the means showed that intentional balancing postures were significantly higher in the last transit sampling period than in all other transit periods ($P < 0.05$). Relaxed behaviour was significantly higher during the last transit sampling period in comparison to the first ($P < 0.05$) (Fig. 5).

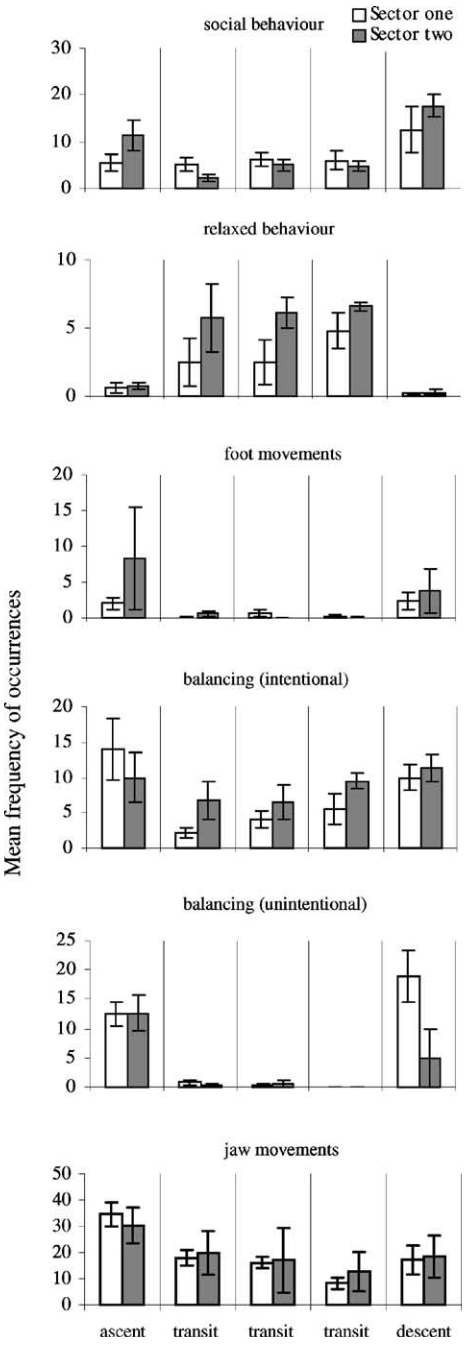

Fig. 5. Mean frequency (±S.E.) of each behaviour category during ascent (including take off), transit periods and descent (including landing) in both sectors of all long haul flights ($n = 4$).

None of the behaviours were significantly different between the first and second ascent and descent (Fig. 5).

During transit, relaxed behaviour increased (Fig. 5), and horses tended to rest a hindleg more. During ascent and descent, relaxed behaviour decreased and horses tended to stand with their hindlegs in a normal position (i.e. hooves square on the floor). In fact no horse was seen to rest a hindleg during the 30 min ascent or descent periods. The horses were seen to rest their hindlegs during all transit periods (mean proportions (±S.E.) ranged from 0.3 ± 0.2 to 0.6 ± 0.1). An ANOVA showed these proportion were not different across different phases of transit ($F(6, 30) = 0.80$, not significant). An ANOVA across all phases of the flight was significant ($F(10, 50) = 6.12, P < 0.05$) and pairwise comparisons across all pairs of events showed that horses rested their hindlegs significantly more during transit than during any ascent or descent.

3.2.3. Comparisons between short and long haul flights

Student's t-tests (d.f. = 21) were conducted to compare peak heart rates across the last parts of both short and long haul flights. The corrected significance level using the Bonferroni adjustment was 0.004 (as there were 11 comparisons). There were no significant differences for any of these comparisons. The t-values obtained were short haul transit versus second long haul transit ($t = 1.64$, not significant), landing ($t = 0.42$, not significant), unloading the aircraft ($t = -1.57$, not significant), transport across the tarmac ($t = 1.83$, not significant) and unloading the stalls ($t = 0.79$, not significant) on short and long haul flights.

Student's t-tests were also used to compare behaviour on the short and long haul flights. In all but one case the behaviour observed during the last period of long haul flights was not significantly different from behaviour seen in the same period of the short haul flights (corrected significance level 0.016). Social behaviour, however, was recorded significantly more often during the last phase of transit on the long haul flights than during transit on the short haul flights.

3.2.4. Body temperature

Rectal body temperature was measured for nine horses before and after transport. Mean body temperatures (±S.E.) were higher immediately after unloading ($\bar{x} = 38.3\,^{\circ}\mathrm{C} \pm 0.2$) than before transport ($\bar{x} = 37.6\,^{\circ}\mathrm{C} \pm 0.2$). Body temperatures were closer to pre-transport levels for most horses when measured 8 h post-transport ($\bar{x} = 38.0\,^{\circ}\mathrm{C} \pm 0.1$). One horse, which was described by a veterinarian as being very dehydrated on arrival, had an elevated temperature at this time (pre-transport = 37.1 °C, on arrival, 8 and 16 h post-transport all = 38.3 °C). Body temperatures measured at 16 h post-transport were similar to those at 8 h ($\bar{x} = 37.9\,^{\circ}\mathrm{C} \pm 0.1$). During a 19-h delay on one flight, the mean RH was 80.3% and the mean air temperature was 22.3 °C. After unloading from the delayed flight, one horse had the highest body temperature (39.1 °C) recorded in the study.

4. Discussion

The results from this study indicate that the behaviour and heart rates of horses were influenced by the process of air transport. During the truck journey to the airport, heart rates were highest during loading and at the very beginning of the journey. Most of the horses' heart rates gradually decreased, although not to resting levels, and stayed fairly steady for the rest of the journey. These results are comparable to those reported by Smith et al. (1994) who also found that heart rate decreased over the course of the road journey. Heart rates of the horses in the present study fluctuated during the journey, possibly due to balancing during deceleration, acceleration and sudden braking or cornering. It was not possible to record vehicle movements, however, heart rates decreased, close to resting levels, when the vehicle was stationary at the airport. These results are similar to those of Waran and Cuddeford (1995) and Smith et al. (1994) who found that the horses' heart rates were significantly higher in a moving vehicle. The results from the present study also suggest that most horses adapt fairly quickly to the truck environment, although not entirely to the movement of the vehicle.

For short haul flights, the highest heart rates were recorded when horses were unloaded from the truck onto the tarmac and when they were unloaded from the aircraft at the end of the journey. Waran et al. (1996) found that horses' heart rates were higher when they were loaded than when they were unloaded from the truck, at the same site, following a round-trip road journey, and speculated that this may be because unloading is less strenuous. In the present study, some of the increase in heart rate during unloading the truck and the aircraft could be due to the horses being unloaded into unfamiliar surroundings. During unloading of the aircraft, the horses were not required to expend energy walking down a ramp, because they were unloaded via a hydraulic lift; however, some energy may have been required to maintain balance during this time, which could have caused a slight increase in heart rate.

The use of balancing postures was most frequent during ascent and descent, and heart rate levels increased during these times. During transit, balancing postures and heart rate decreased and relaxed activities increased. In comparison, during road transport, Waran and Cuddeford (1995) found that horses stood with their forelegs forward and apart and hindlegs apart, in order to maintain balance. The heart rate of most of the horses decreased fairly rapidly during the steady aircraft ascent, after the moment of take off. Thornton (2000) found similar heart rate changes of horses during take off and landing. In the present study, during transit, heart rate was significantly lower than all other events, except during the resting period before transport. In comparison, during the road journey, heart rates did not reach resting levels. Travelling time to the airport never exceeded 147 min, however, Waran et al. (1993) found that even after a 6 h road journey, horses' heart rates never reached resting levels. These results suggest that once the aircraft was in flight, most of the horses adjusted fairly quickly to the aircraft environment and were calmer than they were during road transport. This is probably because there was less movement in the aircraft and the horses did not have to continually maintain balance as they do in a truck. When the aircraft started to descend, the heart rate of most horses increased as soon as the aircraft's engine geared down and the aircraft started to lose altitude. This may have been due to factors such as changes in pressure, noise and/or motion. The heart rate of most of the horses peaked when the aircraft landed. In comparison, the heart rate peaks during take off were very brief and appeared to correlate with the aircraft lifting off the ground.

Waran and Cuddeford (1995) suggested that some of the increase in horses' heart rates in a moving vehicle could be attributed to greater energy expenditure associated with maintaining balance. This may have been the case during ascent and descent, when balancing postures were most frequent. However, increases in heart rate can also indicate arousal of the sympathetic nervous system (Smith et al., 1991). Therefore, some of the increase in heart rate may be attributed to alarm or fear (non-motor changes). Baldock and Sibly (1990) reported non-motor increases in the heart rates of sheep during transport.

There is evidence to suggest that some of the increases in heart rate during this study were non-motor. For example, the horses were unable to walk around or lie down, therefore, motor changes in heart rate could only be due to adjustments in body postures while standing. During ascent and descent, when balancing postures were most frequent, the heart rate of some horses increased to levels comparable to a horse trotting (120–140 beats per min) (Snow and Vogel, 1987). Trotting would require a greater amount of energy expenditure than standing in one place and adjusting body posture. Some of the non-motor changes in heart rate during the air transport procedure may be due to factors such as exposure to an unfamiliar environment, being handled by unfamiliar humans, being subjected to the presence of other unfamiliar horses and exposure to sudden changes in noise and vibration, which mostly occur during transitional phases, such as loading and unloading.

In both types of journeys we examined (long and short haul), the longest part of the journey was when the horses were in transit, and throughout this time heart rate was close to resting levels. Sharp increases in heart rate were transient throughout the transport procedure and were probably not prolonged enough to be of concern to the horses' well being. Behaviour indicative of poor welfare, because they may cause injuries to the horse, such as losing balance and kicking and hitting the sides of the stall, occurred during ascent and descent. However, the events observed here were not severe enough, frequent enough, or prolonged enough, to be of concern to the welfare of the horses.

Eating and jaw movements, such as chewing, which was often accompanied by yawning and shaking or tilting the head from side to side, were observed mainly during ascent and descent. This behaviour may be associated with horses' ears being blocked, due to the pressure changes. Rollier (1985) suggested that eating hay during ascent and descent may help to ease ear pressure for horses during flight. It may be beneficial for the horses to be offered hay during short haul flights as well as long haul flights. Often, horses exposed to environmental stressors are disinclined to eat or drink. Waran and Cuddeford (1995) suggested that horses may be unable to eat during road transport because of the need to maintain balance. In the present study, horses were observed to eat throughout the long haul journeys. This suggests that during the flight, horses were relaxed enough to eat comfortably.

Increased aggressive behaviour has also been suggested as a possible indicator that the animal is not coping with its environment (e.g. Scheepens et al., 1991; McCall et al., 1985). In the present study, social behaviour in general increased during ascent and descent. However, the type of social behaviour that the horses displayed during these times was highly variable. Some horses were quite aggressive and continuously tried to bite the neighbouring horse while others tended to lean their heads into the neighbouring horse during ascent and descent. On one long haul flight, a horse incurred minor injuries from bites from the adjacent horse (possibly because there was no partition separating them). Therefore, it may be beneficial to ensure partitions are used at all times to separate horses.

During a 19 h delay on another long haul flight, some horses also incurred minor injuries due to bites from their neighbours. Aggressive behaviour may increase when animals are exposed to various environmental stressors, such as changes in air temperature (e.g. Scheepens et al., 1991). The high humidity and air temperature levels during the delay may have facilitated an increase in aggressive behaviour in some horses. The average RH and air temperature levels during the delay (80.3% and 22.3 °C) exceeded the recommended range for horses (45–50% and 10–21 °C) (IATA, 1998).

There were fluctuations in air temperature and RH within the aircraft during this study. Leadon et al. (1990) also found that air temperature and RH was higher during stationary periods compared to during transit. Overall, air temperature stayed within the range recommended for horses by IATA (1998), which was 10–21 °C (optimum 16–18 °C). However, during transit, the mean RH over all the flights (means ranged from 27 to 75%) exceeded the recommended range for horses (45–50%) (IATA, 1988). Art et al. (1995) suggested that increases in RH may hinder a horse's ability to thermoregulate. RH reached 100% during some stationary periods, however, this was only over short periods.

Increasing the length of the air transport journeys had little effect on the behaviour or heart rates of horses. The procedures that influenced horses' heart rates and behaviour during short haul flights affected them in a similar way on long haul flights. In general, horses were just as responsive to the second take off and landing as they were to the first on long haul flights, which suggests that horses may not adapt to these events over time. Heart rates at the end of long haul flights, during landing, unloading the aircraft, transport across the tarmac and unloading the stalls, were similar to those seen on short haul flights.

Both the average resting heart rate and the average heart rate during transit were significantly lower than that recorded at any other part of the transport procedure, for both long and short haul flights. During transit, horses tended to relax and rest a hindleg more often compared to during ascent and descent and horses relaxed more during the last phases of transit on long haul flights. Horses also displayed more intentional balancing postures toward the last phases of transit than the first phases. As the behaviour defined as shifting weight was included in the intentional balancing behaviour category, this effect may have been due to the need to shift weight after standing for a long period of time.

On the long haul flights, heart rate during the first sector of the flight was similar to that seen in the second sector. Thus, increasing the length of the journey did not affect horses' heart rates. In addition, there were no differences in behaviour observed between the short and long haul flights, thus the longer journey did not affect behaviour. There were no differences in heart rate between flights due to the stall type (i.e. open or closed). Thornton (2000) also found that there was no significant effect on heart rate due to the stall type.

Overall, body temperatures were higher when measured immediately following unloading the aircraft than they were when measured prior to transport, but they were at pre-transport levels when measured 8 h following unloading. In the present study, it was noted that many of the horses on the long haul flights failed to drink, despite being offered water. Road transport studies have shown that during long road journeys, horses reduce their feed and water intake and this causes a reduction in body weight (Foss and Lindner, 1996; Mars et al., 1992) and dehydration (Van den Berg et al., 1998). To confirm whether this occurs on long haul flights it would be necessary to measure the horses water and food intake.

In conclusion, horses appear to adjust well to travelling by air, and air transport procedures may have less detrimental effects on horses' overall welfare than road transport. Horses had lower heart rates, and presumably required less energy to maintain balance, when they were travelling by air compared to travelling by road. The brief but high increases in heart rate, which occurred during loading and unloading the truck, the stalls and the aircraft, and the changes in behaviour and heart rate during take off and landing, showed that it is during these transitional events that horses are most reactive. At least some of these high peaks appeared to be related to non-motor changes in heart rate, such as exposure to an unfamiliar environment or event, but some may simply be associated with maintaining balance during ascent and descent. Behaviours indicative of poor welfare and high heart rates were probably not frequent enough or prolonged enough to affect the horses' long term welfare. Increasing the length of the flight had little effect on horses' behaviour and heart rate. Horses were more relaxed towards the end of long haul flights, however, they did not adapt to repeated take offs and landings over time. Increasing the length of the journey had little effect on the stress indicators used in this study, however, further research into the effects of journey length on other indicators, such as dehydration, would be useful, especially for horses that are required to compete shortly after travelling.

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