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# Shrink and mortality of beef cattle during long distance transportation

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## Abstract

*The aims of this study were to determine the effects of long distance transport on shrink and mortality rate in cattle, and to understand the relationships between environmental temperature, bodyweight, shrink and dressing percentage. This survey was conducted on 121 transfers of bulls (*Bos taurus*) from commercial finishing units in Bugyi, Hungary to a public slaughterhouse in Ankara, Turkey between July and December 2010. A total of 3,874 bulls were transported and the journeys took approximately 30 h, including a 2-h rest period with water and feed available. In order to investigate the effect of thermal stress, the deviation of the average monthly ambient temperature from average six-monthly temperature was determined (*d-value*). Weight loss during transport and dressing percentage were determined monthly. The effect of month on shrink during transport was significant and average transport shrink was 5.57% during the six months. In general, the highest shrink rate was observed in the summer (August: 8.39%) and winter months (December: 7.27%), both of which are outside the thermoneutral zone for beef cattle. The lowest shrink rate was observed in the autumn months (October: 2.99%, November: 1.77%), which is within the thermoneutral zone. The mortality rate was 0.464% during transportations. Mortality rate was high but the effect of month on mortality rate was not significant. There was a moderate positive correlation between transport shrink and *d-value*. In conclusion, transportations within thermal comfort zone range and good quality animal handling are recommended in order to prevent the adverse effects of long distance transportation, such as shrink and mortality.*

**Keywords**: *animal welfare, cattle, dressing percentage, road transport, thermal stress, weight loss*

## Introduction

Beef cattle (*Bos taurus*) are normally transferred several times during their lifetime and transportation by road is the most common method (Philips *et al* 1991). Truck transportation is a stressor even under optimal conditions because of its adverse effects on production and health of beef cattle (Blecha *et al* 1984; Murata *et al* 1987; Grandin 2000; Arthington *et al* 2003). The process is often aggravated by exposure to conditions such as feed and water restrictions, or environmental insults such as extremes of heat or cold (Kenny & Tarrant 1987). Therefore, the physiological stress produced during long transport journeys negatively affects the welfare of cattle (Tarrant *et al* 1992; Knowles *et al* 1999).

Long distance transport may cause impaired immune function, bodyweight loss, increased morbidity and death (Knowles *et al* 1999; Coffey *et al* 2001; Gallo *et al* 2003). The bodyweight of cattle decreases during long distance transportation; this is the most common change and is known as shrink (Hutcheson & Cole 1986). Shrink involves body waste and tissue losses. Although transportation conditions have improved in recent years, shrink is a natural physiological process which is inevitable (Harman *et al* 1989).

Shrink is a very variable factor that affects the cattle producer negatively during buying and selling cattle (Coffey *et al* 2001). The income of cattle producers is directly affected by shrink. Type of transportation, distance transported, loading density, transport time, temperature, age, sex, pre-transport diet, body condition and pre-transit management are factors that influence shrink and mortality rate. Shrink and mortality rate may also be highly affected by climatic conditions (Camp *et al* 1981; Philips *et al* 1991).

González *et al* (2012) stated synergistic effects between transportation duration and environmental temperature determining that shrink increased in cattle after 30-h transportation at higher environmental temperatures. The shrink of 72 steers averaged 8.3% after 24-h transportation in the study of Tarrant *et al* (1992). Their study was conducted under ambient temperatures ranging from 3.6 to 16.4°C. In a study by Warriss (1990), the shrink value of cattle was 3–11% after 24-h transportation, while it was about 8% after 24-h transport in the studies of Shorthose (1965) and Lambooy and Hulsegge (1988).

The death of animals during transportation for slaughter is a main factor indicating the level of welfare in transported animals (Malena 2007). Mortality rates of other farm animals, such as swine (*Sus scrofa*) and poultry (*Gallus domesticus*), are higher than adult cattle transported by road (Knowles 1999). Henning (1993) reported a mortality rate of 0.01% for slaughter cattle. González *et al* (2012) studied transport conditions during commercial long distance transport of cattle (≥ 400 km; 6,152 journeys; 290,866 animals). Overall, 0.011% of assessed animals died during transportations. In the same study, they reported increases in mortality, becoming non-ambulatory and becoming lame when transportation exceeded 30 h. There is a paucity of information about shrink during long distance transportation compared to shorter distances. The purposes of this study were to determine the effects of long distance transport on shrink and mortality rates of cattle, and to understand the relationships between environmental temperature, bodyweight, shrink and dressing percentage.

## Materials and methods

### Study animals, transportation procedures and transportation vehicles

This survey was conducted on 3,874 bulls (96% Hungarian Simmental; 4% Limousin, Hereford and Angus) moved in 121 transfers between July and December 2010. Their average age was 24 months and the average bodyweight was 572 (± 6.10) kg. Transportation was from Bugyi, Hungary (latitude 47° 13' N, longitude 19° 9' E and 101 m above sea level) to Sincan Slaughterhouse in Ankara, Turkey (latitude 39° 57' N, longitude 32° 34' E and 790 m above sea level). Cattle had free access to water, dry clover and concentrated feed up to approximately 4–5 h before transportation and weight was recorded immediately prior to transportation.

Transportation commenced between 1900 and 2000h and the 1,800 km journey took approximately 30 h, including a 2-h rest period (after 14 h) in which water and feed were made available in the truck. All animals received the same commercial concentrate feed (14% CP and 2,750 kcal $kg^{-1}$ DM of ME) containing barley, wheat, corn, sorghum, rye, wheat bran, rice bran, sunflower meal, cottonseed meal, soybean meal, full fat soy, malt grass, corn gluten feed, vegetable fat, molasses, salt, limestone, dicalcium phosphate, vitamin and mineral premix. The cattle received 0.5 kg per animal of concentrate feed and had continuous access to water and dry clover hay during the rest period. The animals also had free access to water by water storage tank (capacity of 900 L) during transfers. Information about the temperatures during journeys was obtained from the National Oceanic and Atmospheric Administration (NOAA [2010]) along the route. In order to investigate the effect of thermal stress during transportations, as in the study of Malena *et al* (2006), the deviation of the average monthly ambient temperature from average six-months' temperature (15.8°C) was determined (*d*-value).

Transfers were made with two Volvo vehicles and by two drivers for each vehicle. Both vehicles had the same specifications and used the same route. The dimensions of the 'double-deck possum belly' trailers of the vehicles were 16.2 × 2.59 × 4.06 m (length × width × height) and the space availability was 3.8 $m^2$ per animal.

### Lairage, transportation shrink and slaughter procedure

The lairage time of the cattle was 24 h and the available surface area per head in the resting box in roofed pens was 2.8 $m^2$. The pens had concrete flooring and metal fences. Wood-shavings were spread on the floor of the pens. Initially, all animals had continuous access to water and dry clover. With 12 h or less until slaughter, they were provided only water *ad libitum*. Their bodyweights were recorded immediately before slaughter. Shrink was determined by dividing the difference between the weight before transportation and before slaughter by the weight before transportation and the product was multiplied by 100. The carcases were held for 15 min after slaughter and then individual hot carcase weight was determined. The dressing percentage was calculated by dividing hot carcase weight by the weight before transport and then the product was multiplied by 100.

### Statistical analysis

Data were analysed using the Proc GENMOD procedure of SAS (2009). The model included the fixed effect of month and the random effect of animals. The Tukey's multiple comparison test procedure was used to assess differences between means and the structure of data was examined with Pearson Correlation. In this model, temperature and month were not included as separate variables. The effects of month on the variables were determined. The maximum and minimum temperatures were given by months in order to discuss animal welfare variables both inside and outside the thermoneutral zone.

## Results and Discussion

Space availability per animal was 3.08 $m^2$ during transportation (within the recommendations of the European Commission 2006). Space availability per head in the vehicle and bodyweight prior to transport is given, by month, in Table 1. The effects of month on average bodyweight before transportations and the space availability per animal during transportations were not significant ($P > 0.05$).

The average bodyweight of transported animals before slaughter (539.83 kg), carcase weight (307.30 kg) and dressing percentage (53.71%) are provided in Table 2. The effect of month on dressing percentage was shown to be significant ($P < 0.001$). The highest dressing percentages of 55.59% and the lowest of 51.91% were determined in November and July, respectively. These differences may be due to differences in feeding prior to transportation. Researchers found that dressing percentages decreased with increasing dietary roughage levels (Coffey *et al* 1997; Barnes *et al* 2007). In these studies, cattle that are fed a high roughage diet, such as hay, silage or pasture, have a lower dressing percentage than those on a high proportion grain diet.

The minimum and maximum monthly temperatures during transportation shrink and mortality rates are given in Table 3. The lowest average minimum temperature was −7.92°C in December, while the highest (32.17°C) was seen in August. The overall average maximum and minimum temperatures were 23.15 and 8.40°C, respectively.

**Table 1 Mean (± SEM) space availability per head in the vehicle and bodyweight prior to transport, by month.**

| Month | Transfers (n) | Animals transferred (n) | Bodyweight before transport (kg) | Space availability per head ($m^2$) |
|---|---|---|---|---|
| | | | ns | ns |
| July | 37 | 1,177 | 590.79 (± 10.00) | 3.11 (± 0.05) |
| August | 12 | 354 | 572.85 (± 17.56) | 3.07 (± 0.09) |
| September | 10 | 332 | 561.03 (± 19.23) | 2.99 (± 0.09) |
| October | 15 | 494 | 560.26 (± 15.70) | 3.06 (± 0.08) |
| November | 22 | 705 | 561.31 (± 12.97) | 3.06 (± 0.06) |
| December | 25 | 812 | 586.42 (± 12.16) | 3.18 (± 0.06) |
| **Overall** | **121** | **3,874** | **572.11 (± 6.10)** | **3.08 (± 0.03)** |

ns: $P > 0.05$.

**Table 2 Mean (± SEM) bodyweight at slaughter, hot carcase weight and dressing percentage by month.**

| Month | Bodyweight at slaughter (kg) | Hot carcase weight | Dressing percentage (%) |
|---|---|---|---|
| | ns | ns | *** |
| July | 548.68 (± 8.89) | 306.18 (± 5.81) | 51.91 (± 0.50)$^{a}$ |
| August | 524.32 (± 15.62) | 309.64 (± 10.21) | 54.28 (± 0.88)$^{ab}$ |
| September | 529.19 (± 17.11) | 289.25 (± 11.18) | 51.85 (± 0.97)$^{b}$ |
| October | 541.79 (± 13.97) | 302.30 (± 9.13) | 53.91 (± 0.79)$^{ab}$ |
| November | 552.44 (± 11.53) | 311.67 (± 7.54) | 55.59 (± 0.65)$^{b}$ |
| December | 542.54 (± 10.82) | 324.78 (± 7.07) | 54.76 (± 0.61)$^{ab}$ |
| **Overall** | **539.83 (± 5.43)** | **307.30 (± 3.55)** | **53.71 (± 0.30)** |

Means in the same column with different superscripts are significantly different.
*** $P < 0.001$; ns: $P > 0.05$.

**Table 3 Mean (± SEM) maximum and minimum temperatures, transportation shrink and mortality rate by month.**

| Month | Average minimum temperature (°C) | Average maximum temperature (°C) | *d*-value (°C) | Transportation shrink (%) | Dead cattle (n) | Mortality rate (%) |
|---|---|---|---|---|---|---|
| | | | | *** | ns | ns |
| July | 18.14 (± 0.58) | 30.51 (± 0.59) | 8.53 | 7.51 (± 0.48)$^{ab}$ | 3 | 0.254 |
| August | 18.42 (± 1.01) | 32.17 (± 1.04) | 9.50 | 8.39 (± 0.84)$^{a}$ | 4 | 1.130 |
| September | 12.50 (± 1.11) | 28.20 (± 1.14) | 4.55 | 5.51 (± 0.92)$^{b}$ | 2 | 0.602 |
| October | 5.29 (± 0.94) | 17.29 (± 0.96) | 4.51 | 2.99 (± 0.75)$^{c}$ | 1 | 0.202 |
| November | 4.00 (± 0.75) | 18.96 (± 0.77) | 4.32 | 1.77 (± 0.62)$^{c}$ | 6 | 0.851 |
| December | –7.92 (± 0.70) | 11.76 (± 0.72) | 13.88 | 7.27 (± 0.58)$^{ab}$ | 2 | 0.246 |
| **Overall** | **8.40 (± 0.35)** | **23.15 (± 0.36)** | | **5.57 (± 0.29)** | **18** | **0.464** |

Means in the same column with different superscripts are significantly different.
*** $P < 0.001$; *d*: deviation of the average monthly ambient temperature from average six months temperature (15.8°C).


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**Table 4 Correlations among transportation shrink and other characteristics.**

| | Bodyweight before transport | Space availability per head | Transportation shrink | Dressing percentage | Hot carcase weight | *d*-value |
|---|---|---|---|---|---|---|
| **Bodyweight before transport** | 1.000 | 0.742** | 0.380** | 0.103 | 0.837** | 0.179* |
| **Space availability per head** | | 1.000 | 0.146 | 0.158 | 0.725** | 0.170 |
| **Transportation shrink** | | | 1.000 | 0.294** | 0.168 | 0.488** |
| **Dressing percentage** | | | | 1.000 | 0.503** | 0.379** |
| **Hot carcase weight** | | | | | 1.000 | 0.203* |
| ***d*-value** | | | | | | 1.000 |

* Correlation is significant at $P < 0.05$.
** Correlation is significant at $P < 0.01$.

The effect of month on shrink during transport was significant ($P < 0.001$). The highest shrink was 8.39% in August, while the lowest were 2.99 and 1.77% in October and November, respectively. These results can be explained with reference to the thermal comfort zone which is between 5 and 25°C and is the most comfortable environmental temperature range for cattle (McDowell 1972). Above the upper critical temperature (25°C) cattle have an increased respiratory rate and rectal temperature, correlated with a diminishing bodyweight (Bitman *et al* 1984).

Bryan *et al* (2010) found a significant positive relationship between THI (Temperature humidity index) and shrink. Shrink increased when the ambient temperature increased during transportation (Self & Gay 1972; Young 1981). As the ambient temperature increased, faecal and urine output were reduced. However, shrink increased with higher ambient temperatures and may have been related to the greater proportion of respiratory loss, presumably at the expense of fluids from body tissue. In the study by Self and Gay (1972), stocker calves tended to shrink more when they were shipped in the summer than in other seasons. Our results are similar to those of Self and Gay (1972). In addition, the lowest shrink occurred in November (1.77%), followed by October (2.99%) and September (5.51%). The maximum and minimum temperature values of 12.50 and 28.20°C in September were the values closest to the comfort zone, followed by the values in October and November.

The most remarkable results in this study were the similar shrink values in December and July, which approximated those of Young (1981). In the study of Philips *et al* (1991), the first group of steers was transported at ambient temperatures between 18 and 34ºC and the second at ambient temperatures between –16 and –6ºC. The shrink of the first group (9.5%) was higher than in the second (7.7%). Villarroel *et al* (2003) found that the transportation in winter was more stressful than in summer months during commercial cattle transportation.

Season, distance and number of cattle transported were recorded by Self and Gay (1972). In the spring and autumn, 571 and 1,755 cattle were transported 979 and 869 km, respectively. The greatest percentage of shrink (8.3%) was recorded in the summer months of July and August when the cattle were purchased from ranches, while the lowest percentage of shrink (6.4%) occurred in the autumn months of October, November and December. In another study, Knowles *et al* (1999) reported an overall mean loss of 7% of the initial bodyweight after 31-h transportation. Their study was carried out in July and the ambient temperature was between 15 and 30ºC. Results of the present study were similar to theirs. Eighty steers transported for approximately 1,450 km experienced shrink of 7.76% (Embry *et al* 1968), while 1,294 cattle were transported about 1,900 km in eleven separate transfers and had a shrink value of 9.47% (Addis & George 1969). Hale *et al* (1967) reported that 72 steers transported 1,500 km had a shrink value of 10.8%.

Researchers in North America stated an average shrink of 8% after 48-h transportation (Schwartzkopf-Genswein *et al* 2006). Tarrant *et al* (1992) reported an average shrink of 8.3% in 72 steers after 24-h transport at ambient temperatures ranging from 3.6 to 16.4°C. Lambooy and Hulsegge (1988) reported an average shrink of 8% after 24-h transport by road. In an earlier study, Mayes *et al* (1979) reported shrink in cattle of 2 and 6.3% after 5- and 26-h transportation, respectively, in the USA. Animals transported for 5 h lost an average of 4.6% of their bodyweight, whilst animals transported for 10 h lost 6.5% and those transported for 15 h lost 7.0% (Warriss *et al* 1995). Gallo *et al* (2001) reported that animals lost 6.0 to 8.9% of bodyweight after 12-h transportation and 10.5 to 11.9% after 24-h transportation. These results are higher than the results of current study. These differences may be due to differences in transportation duration and the receipt of feed and water. In these studies, cattle did not receive feed and water during transportation and lairage period whereas, in the current study, feed and water were given.

In addition, the differences in rearing and feeding conditions, breed, fatness, animal response to stress, environment, climatic conditions and transport conditions may have contributed to the differences reported (Wythes *et al* 1981; Tarrant *et al* 1992; Warriss *et al* 1995; Grandin 1997; Knowles *et al* 1999).



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Henning (1993) reported a mortality rate of 0.01% in cattle being transported by road for slaughter in 1980. Gregory (2007) reported that stock owners are concerned when mortality rates are excessive and that all the possible causes should be examined, including consideration of poor welfare conditions. The same author recommended that the mortality rate should not exceed 0.005% in beef cattle transported for slaughter. González *et al* (2012) found increases in mortality, becoming non-ambulatory and becoming lame when transportation exceeded 30 h. Overall, 0.011% of assessed animals died during transportations. In the current study, the effect of month was not significant ($P$ > 0.05) and the mortality rate was much higher than these studies.

Malena *et al* (2007) found that the lowest mortality rates occurred at short transport distances (< 50 and 51–100 km), as compared to long distances (101–200, 201–300, and > 300 km) for beef cattle. They reported that with travel distance up to 50 km the mortality rate was 0.004 (± 0.002)%, whereas at long travel distances over 300 km the mortality rate was substantially higher, reaching 0.024 (± 0.027)%. In the current study, mortality rate was much higher. This can be explained by the greater transport distance. In the present study, it was much longer than that of Malena *et al* (2007). Another reason may be the lack of ventilation in the current study. These negative effects could have brought about impaired health and higher mortality. Malena *et al* (2006) stated that the highest mortality rate was in the summer (in particular, July and August) and winter months (particularly January and February), whereas the effect of month on mortality rate was not significant ($P$ > 0.05) in our study. This can be caused by factors such as poor air quality within the vehicle or driving conditions except thermal stress. Wikner *et al* (2003) emphasised driving quality, handling during loading and unloading and air quality in the vehicle. Grandin (2001) stated that the condition of the animals and the quality of the handling facilities are important during long distance transportation. If these conditions are negative then these may become critical factors leading to impaired health and finally to death (Malena *et al* 2007).

The correlations between bodyweight, space availability per animal, dressing percentage, carcase weight and $d$-value are shown in Table 4. The greatest correlation was determined between shrink and $d$-value ($r$ = 0.488, $P$ < 0.01). There were also significant correlations between shrink and dressing percentage ($r$ = 0.294, $P$ < 0.01) and between bodyweight and shrink ($r$ = 0.380, $P$ < 0.01).

## Conclusion

Three thousand, eight hundred and seventy four cattle were transported approximately 1,800 km in 121 separate transfers during a six-month period. The highest shrink rate observed was in August (8.39%) and December (7.27%), both of which are outside the thermoneutral zone for beef cattle. The lowest shrink was observed in October (2.99%) and November (1.77%), which is within the thermoneutral zone. The effect of month on mortality rate was not significant and the mortality rate was 0.464%, which was relatively high. Shrink increased with the extreme of heat or cold whereas it decreased within the thermal comfort zone. In conclusion, the current study suggests that transportation duration above 30 h should be avoided, particularly during extreme climatic conditions. Good quality handling during loading and unloading, good air quality and driving during transport and systems adjusting seasonal air temperature in the vehicle are recommended in order to prevent the adverse effects of long distance transportation, such as shrink and mortality.

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