No appreciable change in kangaroo carcase weights during cold storage: Implications for compliance with minimum harvest carcase weight restrictions

Adam J. Munn
University of Sydney, amunn@uow.edu.au

Nicole Payne
NSW Department of Environment and Climate Change

Follow this and additional works at: https://ro.uow.edu.au/scipapers

Part of the Life Sciences Commons, Physical Sciences and Mathematics Commons, and the Social and Behavioral Sciences Commons

Recommended Citation
No appreciable change in kangaroo carcase weights during cold storage: Implications for compliance with minimum harvest carcase weight restrictions

Abstract
The commercial harvest of kangaroos in Australia is regulated by various state government agencies. They control the number of kangaroos that can be harvested annually with the view to ensuring that the harvest remains ecologically and economically sustainable. In addition to controlling the harvest quotas, some agencies impose minimum weight restrictions on harvested animals, which may assist with maintaining viable breeding populations. However, harvesting usually occurs in remote regions and carcases may be stored refrigerated for up to 10-14 d before being inspected for compliance with minimum weight restrictions. Consequently, there is concern that weight loss during cold storage, particularly in small carcases close to the minimum limit, could lead to harvesters being wrongly prosecuted or fined for breaching the minimum carcase weight licence condition. We found that for two species of kangaroo, the large eastern grey kangaroo (Macropus giganteus; liveweight 30-70 kg) and the smaller red-necked wallaby (M. rufogriseus; liveweight 10-24 kg), carcase weight loss after 10 days cold storage was negligible. There was no significant effect of species on carcase weight change after 10 days cold storage and their pooled weight change averaged just -75.0 ± 18.0 g, or 0.35 ± 0.08% of initial carcase weight. This level of weight loss was significantly different from a hypothesised weight change of zero (Z = -4.17, P < 0.001). However, after an additional four days of cold storage, average weight change in the smallest carcases (the red-necked wallabies) was not significantly different from zero (Z = -1.65, P > 0.05).

Keywords
Carcase dehydration, kangaroo, marsupials, harvesting

Disciplines
Life Sciences | Physical Sciences and Mathematics | Social and Behavioral Sciences

Publication Details

This journal article is available at Research Online: https://ro.uow.edu.au/scipapers/504
No appreciable change in kangaroo carcase weights during cold storage: implications for compliance with minimum harvest weight restrictions.

Adam J. Munn*, and Nicole Payne

1School of Biological Sciences, The University of Sydney, Sydney NSW 2006, Australia
Fax +61 2 9351 4119; Phone +61 2 9351 2932; email adam.munn@bio.usyd.edu.au

2NSW Department of Environment and Conservation, PO Box 2111, Dubbo NSW 2830, Australia
Fax +61 2 6884 8675; Phone +61 2 6883 5343; email nicole.payne@environment.nsw.gov.au

*To whom correspondence should be directed

Running Title: Kangaroo carcase mass during storage

Keywords: Carcase dehydration, kangaroo, marsupials, harvesting
Abstract

The commercial harvest of kangaroos in Australia is regulated by various state government agencies. These agencies control the number of kangaroos that can be harvested annually with the view of managing harvests for ecological and economic sustainability. In addition to controlling the harvest quotas, some agencies impose minimum weight restrictions on harvested animals, putatively maintaining viable breeding populations. However, harvesting usually occurs in remote regions and carcasses may be stored refrigerated for up to 10-14 d before they can be inspected for compliance with minimum weight restrictions. Consequently, there is concern that weight loss during cold storage, particularly in small carcasses close to the minimum limit, could lead to harvesters being wrongly prosecuted or fined for breaching the weight restrictions. We found that for two species of kangaroo, the large eastern grey kangaroo (*M. giganteus*; liveweight 30-70 kg) and the smaller red-necked wallaby (*M. rufogriseus*; liveweight 10-24 kg), carcase weight loss after 10 days cold storage was negligible. There was no significant effect of species on carcase weight change after 10 days cold storage and their pooled weight change averaged just \(-75.0 \pm 18.0\) g, or 0.35 \(\pm\) 0.08\% of initial carcase weight; this was also not significantly different from a hypothesised weight change of zero (Z = -4.17, \(P < 0.001\)). Initial carcase weight was a significant co-variate for weight change after 10 days and larger carcasses lost more weight than smaller carcasses, but again the absolute change was negligible (i.e. < 1.0\% of initial weight). Moreover, after an additional four days of cold storage, average weight change in the smallest carcasses (i.e. the red red-necked wallabies) was not significantly different from zero (Z = -1.65, \(P > 0.05\)).
Introduction

Kangaroo harvesting in Australia is an established and burgeoning industry that contributes around AUS$230 million per annum to Australia’s agricultural sector (Kelly 2005). Traditionally, agriculturalists and pastoralists have viewed kangaroos mainly as ‘pests’, but there is increasing interest in their viability as a commodity in their own right, and particularly as a model for conservation through sustainable use (Grigg 1989; Grigg 2002; Ampt and Baumber 2006). This is particularly so as national and international markets for kangaroo products continue to expand, while sheep and wool prices are declining (Ampt and Baumber 2006). Harvested kangaroos are processed mainly for human consumption or for pet meat, in addition to processing for skins/leather and related products. Additionally, kangaroos may offer indirect economic returns through non-traditional sources like eco-tourism (Croft 2000; Higginbottom et al. 2004). Consequently, recent focus for kangaroo management has shifted away from “pest-management” and toward sustainable harvesting (Anon. 2007), thereby helping to ensure the viability of kangaroos as a useful resource. Moreover, ecologically sustainable harvesting of kangaroos also has implications for their contribution total grazing pressures, particularly in arid and semi-arid sheep rangelands (Olsen and Low 2006; Dawson and Munn, In press).

Five species of large kangaroo are harvested commercially on Australia’s mainland; the red kangaroo (*Macropus rufus*), the eastern (*M. giganteus*) and western (*M. fuliginosus*) grey kangaroos, the common wallaroo/euro (*M. robustus*), and the whip-tailed wallaby (*M. parryi*) (see Olsen and Braysher 2000). In Tasmania, two species of wallaby are also commercially harvested, the Bennetts wallaby (*Macropus rufogriseus*) and Pademelon (*Thylogale billardierii*) (see Olsen and Braysher 2000).
The commercial harvesting of kangaroos is managed at the State level by way of kangaroo management plans (KMPs) or equivalent; governed by the Department of Environment and Conservation (DEC) in New South Wales, The Department of Environment and Heritage in South Australia, The Department of Conservation And Land Management in Western Australia and the Queensland Parks and Wildlife Service as as part of the Environmental Protection Agency in Queensland. Each State’s management plan regulates harvesting through the issuing of hunting tags for commercial culling and also for pest mitigation.

Currently, most kangaroo populations are harvested at around 8-10% of total population per year, which is well below the 10-20% allowable by most KMPs (Olsen and Low 2006; Anon. 2007). This level of harvesting is also well below the maximum levels predicted for sustainable management (McLeod et al. 2004). However, in addition to controlling the total number of animals harvested, there is concern about the age and size structure of the harvested populations (Wilson, 1975; Pople 2003; McLeod et al. 2004). Therefore, most state plans impose strict minimum weight restrictions for harvested animals. The setting of minimum weights aims to avoid harvesting young animals, particularly females, so that they may have opportunity to breed prior to culling, putatively maintaining population recruitment (Pople 2003; Kelly 2005).

The set minimum carcase weight varies between states and according to processing procedures for either human or pet food consumption. In NSW, where this study was carried out, the minimum weight for carcases dressed for human consumption is 13 kg, and 12 kg for carcases dressed for pet meat processing; human consumption carcases must retain the heart, liver and lungs for meat quality testing prescribed by the Australian Standard for Hygienic Production of Game Meat for
Human Consumption (ARMCANZ 1997). In NSW, the DEC regularly inspects harvested carcases to check compliance with these minimum weight restrictions. However, kangaroos are usually collected in remote and regional areas and may be stored in field refrigerators, or chillers, for up to 10 days before being transported to a meat processor (Greg Bates, Vacik distributors, pers. com). Consequently, carcases may be inspected some time after their initial slaughter and there is concern that they may lose weight during cold storage, presumably through dehydration. Consequently, harvesters could be wrongly prosecuted or fined for breaching the minimum weight restrictions. Carcase weight change may also have implications for meat quality (Wynn et al 2004). We therefore investigated the potential for carcase weight loss in two species of kangaroo, the large eastern grey kangaroo (M. giganteus; average liveweight 30-70 kg) and the smaller red-necked wallaby (M. rufogriseus; average liveweight 10-24 kg). By using the smaller red-necked wallabies we were able fully explore the potential for carcase weight change in animals that were below the minimum weight allowed for commercially harvested kangaroos, thereby providing data that encompassed the entire weight spectrum relevant for enforcing compliance.

Methods

Chiller storage conditions
The kangaroo carcases used in this experiment were stored in a typical field chiller (width 2.4 m; height 2.6 m, length 6.0 m). Chiller ambient temperature ($T_a$; ± 0.5 °C) and relative humidity (%RH; ± 0.6%) were measured hourly using a digital temperature/humidity logger (Hygrochron iButton, model DS1923; Maxim Integrated Products, CA USA). $T_a$ and %RH were recorded along the centre of the chiller at the front, mid and rear of the facility.
Animals and carcase weight change

The eastern grey kangaroos (n = 26 males; n = 14 females) used in this study were collected by a professional shooter as part of a commercial harvesting operation in southeastern New South Wales. The animals were collected over one night in accordance with DEC NSW KMP (Anon. 2007) and relevant licenses issued under the National Parks and Wildlife Act 1974. Carcases were dressed at the point of harvest and all carcases were transported to our field chiller (cold storage unit) and refrigerated by 0300 h (i.e. before the prescribed 2 h after dawn; ARMCANZ 1997).

Carcases were dressed for pet meat processing (i.e. total organ evisceration, decapitation and forepaws and feet removed; Fig 1). On entry to the chiller each dressed carcase was weighed to the nearest ± 0.05 kg (Salter Scales, Lansvale, NSW) to provide an initial ‘hot’ weight. Carcases were hung suspended from the right leg and in a manner that allowed air to flow over the entire animal surface and within the thoracic cavity (Fig. 1), with the view of maximising potential for water loss by dehydration.

The red-necked wallabies (n = 3 males; n = 5 females) used in this study were collected as part of a separate study conducted by Munn et al. (unpublished). Red-necked wallabies are not commercially harvested in NSW, but their average body mass is at the low end of the typical weight range for the four large species of commercially harvested kangaroo. Because all macropodids (kangaroos and wallabies; family Macropodidae) have the same basic body shape and form, we used the red-necked wallabies to investigate carcase weight changes in kangaroos that would normally be well below the legal minimum weights allowed for the larger, commercially harvested species (mainly the red, eastern and western grey kangaroos).
and the euro/wallaroo). The red-necked wallabies were slaughtered by a lethal intracardiac injection of sodium pentobarbitone (160mg kg$^{-1}$) between 0730 h and 0900 h on Day 1 of the experiment. Each carcase was exsanguinated and eviscerated via a ventral incision before being carefully packed into plastic bags and stored cold for transportation. The carcases were then transported to our field chiller within 4.5 h of slaughter. On arrival, the carcases were dressed for pet-meat processing as per the eastern grey kangaroos (above). Carcases were weighed to the nearest ± 0.05 kg (Salter Scales, Lansvale, NSW) and hung suspended by the right leg in a manner that allowed air to flow over the entire animal surface and within the thoracic cavity.

On Day 1 of the experiment all carcases were weighed (± 0.05 kg) between 1400 and 1500 h. Carcases were then weighed at approximately the same time on Days 2, 4, 5, 7 and 10. After ten days the eastern grey kangaroos were removed for processing. The red-necked wallaby carcases were stored for an additional four days before a final weight was measured on Day 14.

**Statistical analysis**

We compared weight changes (absolute change in grams) between initial carcase weights and those on Day 10 of cold storage in the red-necked wallaby and eastern grey kangaroos using a General Linear Model (GLM). Assumptions for GLM were tested using Kolmogorov-Smirnov test for normality and Levene’s test for homogeneity of variances. Initial (‘hot’) carcase weight was square root transformed to achieve normal distribution and homogeneity of variances with respect to species. However, because of the broad range in body weights for the male eastern grey kangaroos (13.7 – 49.9 kg; n = 26) and their overrepresentation in the data compared
females (13.4 – 21.1 kg; n = 14), we could not achieve homogeneity of variances in initial carcase weight for sex. Sex was therefore excluded as a factor from our study, but is also unlikely to be important biologically as male and female kangaroos share the same body shape and form (Fig. 1), with body weight being the primary difference between sexes. Therefore, we investigated carcase weight loss after Day 10 of cold storage using a GLM with species as a random factor and the square root of initial carcase mass as covariate.

To determine whether smaller carcases experienced increased weight loss after additional cold storage, we measured carcase weights of the red-necked wallabies after 14 days cold storage (i.e. Day 14 – initial weight; g). Gross carcase weight change (g) for the red-necked wallabies by Day 10 and Day 14 were compared using a paired, two-tailed t-test. Absolute carcase weight change (g) for the red-necked wallabies on both Day 10 and Day 14 was also compared to theoretical weight change of zero (g) using a one-sample Z-test (Zar 1999).

All stats were performed using Minitab for Windows. Data are presented as means ± standard error of the mean (SEM). Differences were considered statistically different at p £ 0.05.

**Results**

**Chiller storage conditions**

The chiller maintained relatively constant T<sub>a</sub>s throughout the entire experiment, at an average of -0.44 ± 0.08 °C (Fig. 2). Spikes in T<sub>a</sub> were associated with carcases
weighing sessions on Day 1, 2, 4, 5, 7, 10 and 14, but these periods each lasted less
than 1 h, and $T_a$ was quickly restored (Fig. 1).

Average chiller %RH throughout the experiment was 98.0 ± 0.3%. However,
chiller %RH was comparatively low on Day 1 of carcase storage, increasing from ca.
50% at 15:00 h (i.e. 12 h after the eastern grey carcases entered storage, but
immediately following Day 1 weighing) and increasing to around 97% by 09:00 h on
Day 2 and 100% by 0:500 h on Day 3. Troughs in %RH were evident during carcase
weighing sessions on Day 1, 2, 4, 5, 7, 10 and 14 (Fig. 2).

Carcase weight changes

Carcase weight changes for the red-necked wallabies (Fig. 3) and eastern grey
kangaroos (Fig. 4) were relatively constant throughout the entire experiment (see
Table 1). Moreover, there was no significant effect of species on the level of carcase
weight change after 10 days of cold storage (Table 2). Initial carcase weight was not a
significant covariate for absolute carcase weight change after 10 days ($P > 0.05$; Table
2). Overall, when the kangaroo carcases were pooled for species their average weight
change after 10 days was just $-75.0 \pm 18.0$ g, or $0.35 \pm 0.08$% of initial carcase weight
(Table 1). Although small, this level of weight change was significantly different from
a hypothesised weight change of zero ($Z = -4.17$, $P < 0.001$).

There was no significant difference in the absolute weight change (g) of the
red-necked wallaby carcases between Day 10 and Day 14 of cold storage, the values
being $-37.5 \pm 26.3$ g and $-75.0 \pm 45.3$ g, respectively (paired-$t_{(2)} = 1.43$, $DF = 7$; $P >
0.05$; Table 1). Moreover, the levels of carcase weight change (g) for the red-necked
wallabies by Day 10 and Day 14 of storage were each not significantly different from
zero (Day 10, $Z = -1.43$, $P > 0.05$; Day 14, $Z = -1.65$, $P > 0.05$).
Discussion

Putatively, weight loss from properly prepared kangaroo carcases (i.e. eviscerated, cleaned and exsanguinated) could result from residual body water/fluids evaporating via the carcase’ exposed surfaces; through the furred skin as post-mortem trans-epidermal evaporation and from the thoracic and abdominal walls exposed by evisceration. Therefore, it may be expected that smaller kangaroo carcases, particularly those close to the minimum legal weights prescribed for commercial harvesting, could lose more weight during cold storage relative to larger carcases because of their higher surface area to volume ratios. However, we found that the smaller carcases were not more or less likely to lose weight compared with larger carcases. Indeed, the average weight change observed for the smallest of the kangaroo carcases (i.e. the red-necked wallabies) was not significantly different from zero after 10 or 14 days cold storage.

Generally, the macropodid marsupials (kangaroos, wallabies and rat kangaroos) have the same basic body shape and form (Fig. 1). Therefore, that we found no significant effect of kangaroo species on carcase weight changes after 10 days cold storage (Table 1) indicates that our results should be representative for most harvested species spanning a live-weight range of 5-50 kg, but particularly for the larger red and western grey kangaroos and for the euro/wallaroo. Overall, we found that for carcases prepared for pet meat consumption, the average weight changes after 10 days cold storage was negligible (<0.1% initial carcase mass). It is unlikely therefore that significant weight loss could lead to borderline weight carcases being recorded as underweight as a consequence of dehydration during cold storage of up to 14 days. However, these results are applicable mainly to kangaroo carcases prepared
for pet meat processing, and there are different considerations for carcases prepared for human consumption.

Carcases that are prepared for human consumption are allowed a higher minimum weight restriction to account for the retention of vital organs required for food standards testing (ARMCANZ 1997). These organs include the heart, liver, lungs and kidneys, which are generally high in water content, but it is difficult to predict how these organs might change during cold storage. Nonetheless, for an eastern grey kangaroo at a minimum allowable weight of 13 kg for human consumption (Payne, N. pers. com), and assuming total organ dehydration of 100% (which is very unlikely), the absolute maximum level of carcase weight loss that could be expected would be 7.7% of initial carcase weight. Regardless, further investigation is needed to fully appreciate how carcases prepared for human consumption may change during chiller storage.

Conclusion

Our results provide a useful guide for ensuring compliance with minimum weight restrictions for harvested kangaroos. This is not only important for proper management of kangaroo harvesting (Anon. 2007), but should assist harvesters in improving and maintaining their skills at estimating live body weights in the field.

References


Olsen P. and Braysher M (2000) Situation analysis report: Current state of scientific knowledge on kangaroos in the environment, including ecological and
economic impact and effect of culling. Prepared for the Kangaroo
Management Advisory Committee, The NSW Department of Environment and
Conservation national parks and Wildlife Service (available at
www.environment.nsw.gov.au; follow links to 'Kangaroo Management')

Olsen P. and Low T. (2006) Situation analysis report update on current state of
scientific knowledge on kangaroos in the environment, including ecological
and economic impact and effect of culling. Prepared for the Kangaroo
Management Advisory Committee, The NSW Department of Environment and
Conservation national parks and Wildlife Service (available at
www.environment.nsw.gov.au; follow links to 'Kangaroo Management')

Number 34

Wilson, G R (1975) Age structures of populations of kangaroos (Macropdidae) taken

04/151, Rural Industries Research and Development Corporation, Barton ACT
Acknowledgements

This project was supported by a grant to AJM by the New South Wales Department of Environment and Conservation Kangaroo Management Program. The eastern grey kangaroos were harvesting in accordance with the National Parks and Wildlife Act 1974. The red-necked wallabies were sourced from a separate project conducted by AJM and carried out under New South Wales National Parks and Wildlife licence S11905 and with the approval from the University of New South Wales Animal Care and Ethics Committee (ACEC04/13). Sincere thanks to the professional shooters who participated in this project and to Greg Bates and Vacik Distributors for providing access to harvested carcases and for use of a field chiller. Thanks to Dr Steve McLeod and comments and improvements on earlier versions of this manuscript.
Table 1: Mean (± SEM) change in kangaroo carcase weights after 10 and/or 14 days chiller storage (see text for statistical differences within species; values in parenthesis are as a proportion of initial carcase weight).

<table>
<thead>
<tr>
<th>Species</th>
<th>Initial carcase weight (kg)</th>
<th>Change after 10 days (g)</th>
<th>Change after 14 days (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red-necked (n = 8)</td>
<td>6.2 ± 0.5</td>
<td>-37.5 ± 26.3</td>
<td>-75.0 ± 45.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(-0.60 ± 0.4%)</td>
<td>(-1.2 ± 0.7%)</td>
</tr>
<tr>
<td>Eastern grey (n = 40)</td>
<td>24.7 ± 1.5</td>
<td>-82.5 ± 131.8</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.33 ± 0.5%)</td>
<td>-</td>
</tr>
<tr>
<td>Combined (n = 48)</td>
<td>21.6 ± 1.6</td>
<td>-75.0 ± 18.0</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.35 ± 0.08%)</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 2: General Linear Model for carcase weight changes for red-necked wallabies (n = 8) and eastern grey kangaroos (n = 40) combined, with species as random factor and initial carcase weight (square root transformed) as a covariate.

<table>
<thead>
<tr>
<th>Source</th>
<th>d.f.</th>
<th>F-ratio</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Square Root Initial Carcase Weight</td>
<td>1</td>
<td>2.01</td>
<td>0.163</td>
</tr>
<tr>
<td>Species</td>
<td>1</td>
<td>2.82</td>
<td>0.331</td>
</tr>
</tbody>
</table>
Figure Labels

Figure 1: Kangaroo carcases prepared for pet meat consumption and hung adequately spaced to maximise airflow across the furred surface and within the exposed thoracic cavity.

Figure 2: Average hourly chiller conditions for ambient temperature (Temp; °C) and relative humidity (RH; %) from Day 1 to Day 14 of cold storage.

Figure 3: Initial (Day zero) and daily weights (kg) for the red-necked wallaby carcases measured on Day 1 – Day 14 of cold storage.

Figure 4: Initial (Day zero) and daily weights (kg) for the eastern grey kangaroo carcases measured on Day 1 – Day 10 of cold storage.
Fig. 2

Temperature (°C) vs. Chiller storage days

- Solid line: Temp
- Dotted line: RH

Relative humidity (%) vs. Chiller storage days
Fig. 3

Carcase mass (kg) vs. Chiller storage days for Male and Female.