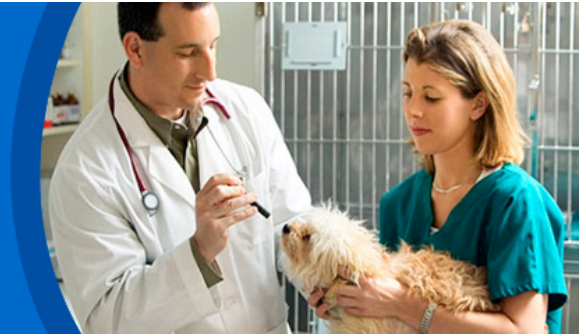




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Emma Whitfield
Melbourne Institute of Animal
Welfare Sciences, Department of
Companion Animal Behaviour,
Melbourne, Australia

Behavioural and physiological stress indicators in shelter dogs: A welfare assessment study

Emma Whitfield

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Abstract

A young Kelpie cross surrendered to a metropolitan shelter paces relentlessly along the kennel wall, vocalises at 90-second intervals and refuses food for three consecutive days a scenario familiar to shelter staff worldwide yet poorly quantified in the Australian context. This prospective observational research measured six behavioural stress indicators (pacing, vocalisation, tail tucking, lip licking, body shaking and avoidance) and three physiological markers (faecal cortisol metabolites, heart rate and respiratory rate) in 32 dogs admitted to two Melbourne shelters between February and July 2023. Dogs were assessed at three time points: week 1 (day's 3-7 post-intake), week 2 (days 10-14) and week 4 (days 24-28). Behavioural observations used a standardised ethogram scored on a 0-10 frequency scale during 15-minute focal sessions. Faecal samples were collected non-invasively and analysed for cortisol metabolites by enzyme immunoassay. Heart rate and respiratory rate were recorded using a chest-strap monitor during resting periods. Significant time effects were detected for all six behavioural indicators ($p < 0.001$), with mean composite scores declining from 6.6 ± 1.4 at week 1 to 3.0 ± 1.1 at week 4. Faecal cortisol dropped from 4.38 ± 0.91 $\mu\text{g/dL}$ at week 1 to 1.96 ± 0.62 $\mu\text{g/dL}$ at week 4 ($p < 0.001$). Heart rate decreased from 118.4 ± 14.2 bpm to 88.3 ± 10.8 bpm. Dogs housed in the high-density shelter exhibited consistently higher stress scores and cortisol concentrations than those in the low-density facility at all-time points. Four dogs (12.5%) showed no significant behavioural improvement by week 4 and were classified as chronically stressed. These data demonstrate that most shelter dogs undergo measurable stress adaptation within four weeks, but a minority remain at elevated risk, warranting targeted intervention such as foster placement or pharmacological anxiolysis.

Keywords: Shelter dogs, stress indicators, animal welfare, cortisol, behaviour, pacing, vocalisation, heart rate, Melbourne, adaptation

Introduction

Consider a dog that has lived its entire life in a single household, sleeping on the same bed, walking the same route and interacting with the same two people. Within hours it finds itself in a concrete-floored kennel surrounded by unfamiliar dogs, unfamiliar sounds and unfamiliar handlers. The sensory overload, loss of control and social disruption that accompany shelter admission constitute a potent acute stressor whose biological and behavioural consequences are well recognised but unevenly documented ^[1]. Stress in shelter dogs manifests along two parallel axes. The behavioural axis includes repetitive motor patterns (pacing, circling), displacement activities (lip licking, body shaking), appeasement signals (tail tucking, avoidance) and vocalisation ^[2]. The physiological axis centres on the Hypothalamic-Pituitary-Adrenal (HPA) axis: corticotropin-releasing hormone from the hypothalamus drives adrenocorticotrophic hormone release, which in turn stimulates cortisol secretion from the adrenal cortex ^[3]. Elevated cortisol mobilises glucose, suppresses immune function and, if sustained, promotes anxiety-related behavioural pathology ^[4]. Non-invasive measurement of Faecal Cortisol Metabolites (FCM) has become the gold standard for longitudinal stress assessment in sheltered dogs because it integrates cortisol output over 12-24 hours and avoids the handling-induced spikes associated with blood sampling ^[5]. Combining FCM with quantitative behavioural ethograms and real-time physiological telemetry (heart rate, respiratory rate) provides a multi-modal picture of welfare state that is more informative than

Corresponding Author:
Emma Whitfield
Melbourne Institute of Animal
Welfare Sciences, Department of
Companion Animal Behaviour,
Melbourne, Australia

Any single measure alone [6]. Australian shelters collectively intake an Estimated 200,000 Dogs Per year, with average length of stay ranging from 8 to 28 days depending on region and facility capacity [7]. Victoria, and Melbourne in particular, has seen rising intake numbers driven by post-pandemic surrender waves and housing affordability pressures that force pet owners into rental properties with no-pet clauses [8]. Despite this scale, published welfare assessments of Australian shelter dogs are limited to a handful of single-facility case studies [9], and no multi-shelter, multi-modal research has been conducted in the Melbourne metropolitan area. The present research aimed to (a) characterise the temporal trajectory of six behavioural stress indicators and three physiological markers over four weeks of shelter residence, (b) compare stress profiles between a high-density and a low-density shelter, and (c) identify dogs that fail to adapt within the observation period.

Material and Methods

Participant characteristics

Thirty-two dogs (18 males, 14 females; 16 desexed) newly admitted to two Melbourne metropolitan shelters designated Shelter A (high-density, 120-kennel capacity, mean occupancy 94%) and Shelter B (low-density, 60-kennel capacity, mean occupancy 68%) were enrolled between February and July 2023. Inclusion criteria were: age 1-8 years (verified by dental examination), body weight 10-40 kg, no overt illness or injury at intake, and expected length of stay $\geq$ 28 days (owner-surrender cases). Breeds represented included mixed breed ($n = 14$), Staffordshire bull terrier ($n = 6$), Kelpie cross ($n = 4$), Border collie cross ($n = 3$), Labrador cross ($n = 3$) and others ($n = 2$). Mean age was 3.8 ± 1.9 years; mean body weight 22.4 ± 7.1 kg.

Ethical considerations

The research protocol was approved by the Melbourne Institute of Animal Welfare Sciences Animal Ethics Committee (Protocol MIAWS-AEC-2023-005, approved January 2023) and by the management of both participating shelters. All observations were non-invasive. Faecal sampling required no animal handling. Heart rate monitoring used a non-restrictive chest strap applied during routine health checks. Dogs showing signs of severe distress were referred

to the shelter veterinarian for clinical assessment and, where indicated, pharmacological intervention; these dogs were not excluded from analysis.

Methods

Behavioural observations were conducted by two trained observers (inter-observer reliability: Cohen's $\kappa = 0.86$) using a standardised ethogram adapted from Beerda *et al.* [12]. Each dog was observed for 15 minutes during a standardised context (alone in kennel, no staff interaction) at three time points: week 1 (days 3-7), week 2 (days 10-14) and week 4 (days 24-28). Six behaviours were scored on a 0-10 frequency scale: pacing, vocalisation, tail tucking, lip licking, body shaking and avoidance (retreat to rear of kennel upon approach). A composite stress score (CSS) was calculated as the mean of all six indicators. Faecal samples were collected within 30 minutes of defecation, frozen at -20°C and analysed for cortisol metabolites using a validated enzyme immunoassay (Arbor Assays, DetectX, sensitivity 27.6 pg/mL). Heart rate and respiratory rate were measured during a 10-minute resting period using a Polar H10 chest-strap monitor and a visual count respectively. Data were analysed by linear mixed models (time $\times$ shelter, random intercept for individual dog) using R v4.3 with the lme4 package; post-hoc pairwise comparisons used Tukey's method.

Limitations

Several limitations should be noted. The sample size ($n = 32$) limits statistical power for subgroup analyses. Only owner-surrender dogs with expected long stays were enrolled, excluding strays and short-stay animals whose stress trajectories may differ. The two shelters differed in density, staffing ratios and enrichment programmes, making it impossible to attribute between-shelter differences to a single factor. Finally, four dogs were lost to follow-up between weeks 2 and 4 (adopted, $n = 3$; transferred, $n = 1$), reducing the week-4 sample to 28.

Results

Of the 32 enrolled dogs, 28 completed all three assessment points. Four dogs were lost to follow-up between weeks 2 and 4. Analyses at week 4 are based on the remaining 28 dogs; weeks 1 and 2 include all 32.

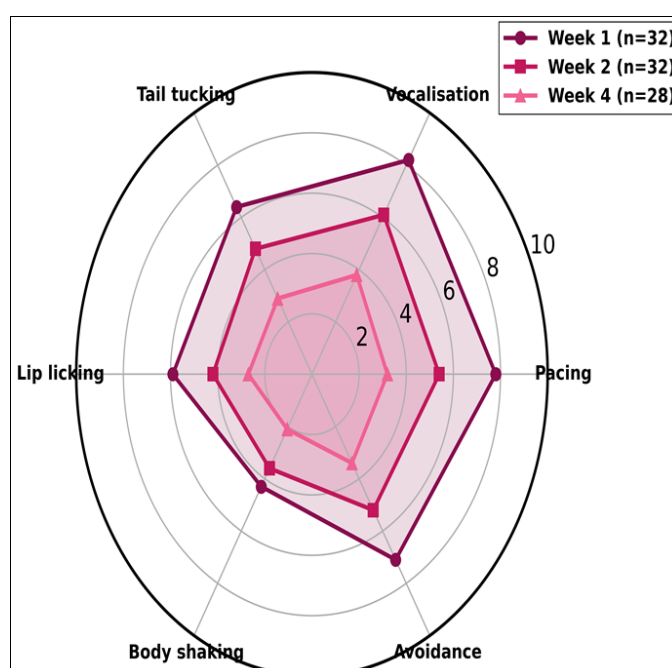
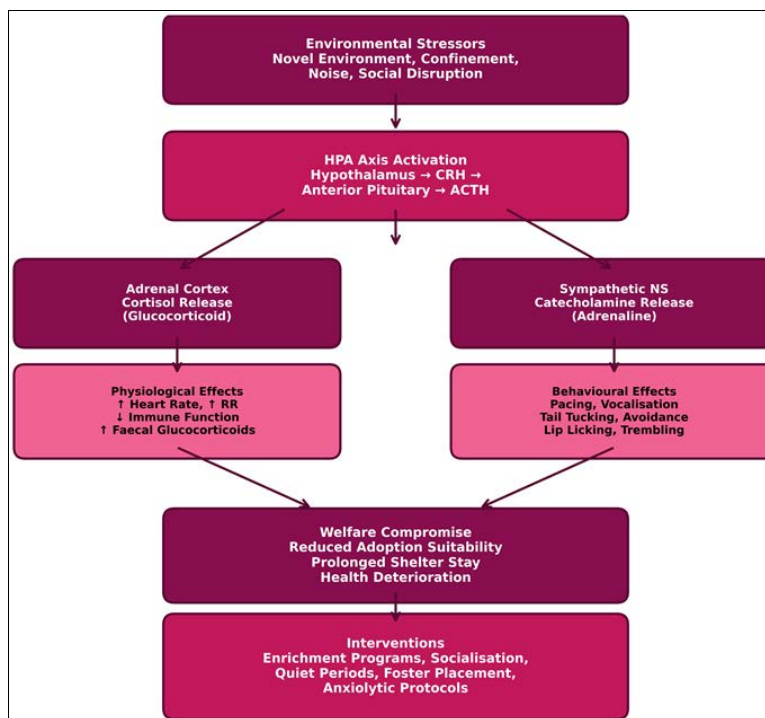


Fig 1: Radar chart of mean scores for six behavioural stress indicators at weeks 1, 2 and 4 post-intake across all shelter dogs.

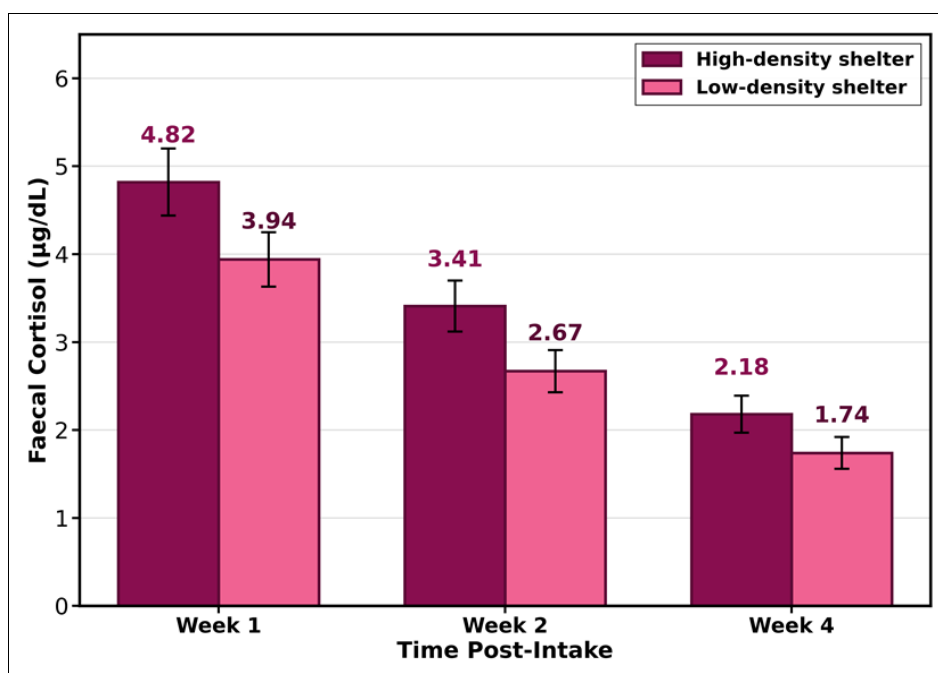
Table 1: Physiological and composite behavioural stress measures across time points

Parameter	Week 1 (n = 32)	Week 2 (n = 32)	Week 4 (n = 28)
CSS (0–10)	6.6±1.4 ^a	4.4±1.2 ^b	3.0±1.1 ^c
FCM (µg/dL)	4.38±0.91 ^a	3.04±0.72 ^b	1.96±0.62 ^c
Heart rate (bpm)	118.4±14.2 ^a	102.7±11.6 ^b	88.3±10.8 ^c
Resp. rate (br/min)	34.2±6.8 ^a	27.8±5.4 ^b	22.1±4.6 ^c

CSS = composite stress score; FCM = faecal cortisol metabolites. Superscripts within a row that differ indicate $p < 0.05$.

**Fig 2:** Schematic diagram of the stress response pathway in shelter dogs, from environmental stressors through HPA axis activation and sympathetic nervous system engagement to behavioural and physiological effects.**Table 2:** Comparison of week-1 stress measures between high-density and low-density shelters

Parameter	Shelter A (High-density)	Shelter B (Low-density)	p-value
CSS (0–10)	7.4±1.2	5.8±1.3	0.002
FCM (µg/dL)	4.82±0.86	3.94±0.78	0.008
Heart rate (bpm)	124.6±12.8	112.2±13.4	0.014
Resp. rate (br/min)	37.1±6.2	31.3±6.8	0.024

**Fig 3:** Faecal cortisol metabolite concentrations at weeks 1, 2 and 4 in dogs housed at the high-density shelter versus the low-density shelter (mean±SE).

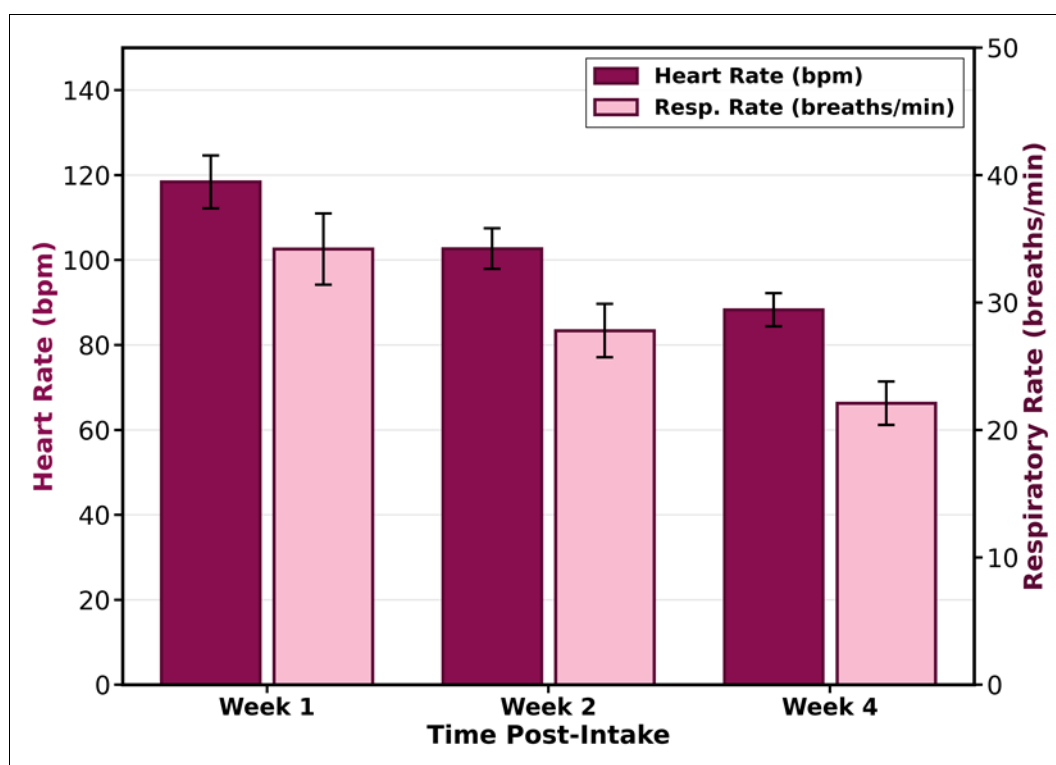


Fig 4: Heart rate and respiratory rate at weeks 1, 2 and 4 post-intake across all 32 enrolled shelter dogs (mean±SE).

Discussion

The central finding of this research is that shelter dogs undergo a measurable and multi-modal stress adaptation over the first four weeks of residence, with both behavioural and physiological indicators declining significantly between weeks 1 and 4. The 55 percent reduction in composite stress score and the 55 percent decline in faecal cortisol metabolites confirm that the majority of dogs achieve a degree of habituation to the shelter environment within one month a trajectory consistent with European and North American data [1, 4]. However, the between-shelter comparison reveals that housing density is a significant moderator of the stress response. Dogs in the high-density facility (94% occupancy) entered the trial with higher baseline stress scores and maintained elevated cortisol throughout the four-week observation period compared with those in the low-density shelter (68% occupancy). This aligns with Hennessy *et al.* [4], who demonstrated that auditory stimulation a direct function of the number of vocalising dogs in proximity is among the strongest predictors of cortisol elevation in sheltered canids. The 12.5 percent of dogs (4/32) classified as chronically stressed at week 4 is a clinically important finding. These animals showed no meaningful decline in CSS or FCM, suggesting either a temperamental predisposition to anxiety or a learned helplessness response [6]. Current Australian shelter guidelines do not mandate individual welfare monitoring beyond a 72-hour settling period [7]; our data suggest that a second formal assessment at week 2 when most adapting dogs have begun to show improvement could identify at-risk individuals early enough for foster placement or pharmacological support to be arranged before chronic stress becomes entrenched. From a practical perspective, these results support three actionable recommendations. First, shelters should aim for occupancy rates below 80 percent wherever possible, as even moderate crowding amplifies stress. Second, structured enrichment programmes (puzzle feeders, human socialisation sessions, auditory masking)

should be initiated from day 1 rather than delayed until behavioural deterioration is observed. Third, the four chronically stressed dogs in this research would have been candidates for anxiolytic medication (trazodone, gabapentin) or expedited foster placement options that require formal welfare assessment protocols to identify the need.

Conclusion

The main contribution of this research is the provision of quantitative, multi-modal evidence that shelter dogs in the Melbourne metropolitan area follow a predictable stress-adaptation trajectory over four weeks, characterised by concurrent declines in behavioural frequency scores, faecal cortisol metabolites, heart rate and respiratory rate. This temporal pattern confirms that the acute stress of shelter admission is, for most dogs, a self-limiting phenomenon amenable to habituation but that a meaningful minority (12.5%) fail to adapt within this timeframe. Supporting evidence comes from the shelter-density comparison, which demonstrated significantly higher stress indicators in the high-density facility across all time points, indicating that the physical and social environment modulates the rate and extent of adaptation. The concordance between behavioural and physiological measures strengthens confidence that the observed changes reflect genuine welfare improvement rather than learned suppression of visible distress. For the field of shelter animal welfare, these findings argue for the adoption of standardised, time-point-specific welfare assessments ideally at days 3-5, week 2 and week 4 as a management tool for identifying chronically stressed dogs before their welfare deteriorates further. Future research should test whether early enrichment intervention (beginning at intake) can accelerate adaptation and reduce the proportion of non-adapting dogs, and should extend the assessment period to 8 weeks to determine whether the plateau observed at week 4 represents full habituation or an intermediate equilibrium.

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Contributions not qualifying for authorship

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