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Behaviour of free-range laying hens in distinct outdoor environments

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Abstract

The outdoor range in free-range, egg-production systems contains features that aim to promote the performance of natural behaviours. It is unclear what features of the range laying hens prefer and how these influence hen behaviour. We hypothesised that hens would demonstrate a preference for features of the environment in which their ancestor evolved, such as relatively dense vegetation, within the outdoor range and that the behavioural time budget of hens will differ between distinct environments. Characteristics of the outdoor range in one free-range commercial egg farm were mapped and four distinct environments ('locations') were identified based on ground substrate and cover (Wattle Tree, Gum Tree, Bare Earth and Sapling). The number of hens accessing each location and behavioural time budget of these hens was recorded over a three-week period during the southern hemisphere summer (January–February). Hens showed a clear preference for the Wattle Tree and Gum Tree locations; however, a significant interaction between location and time of day suggested that the hens' preference for different locations changed throughout the day. The most common behaviours displayed by hens were foraging, preening, locomotion, resting and vigilance, and most behaviours were influenced by the interaction between location and time of day. Overall, a wider variety of behaviours were performed in the highly preferred environments, but not all behaviours were performed equally within each environment throughout the day. Understanding what features hens prefer in the outdoor range and how this influences the performance of natural behaviours is important in promoting the welfare of hens in free-range production.

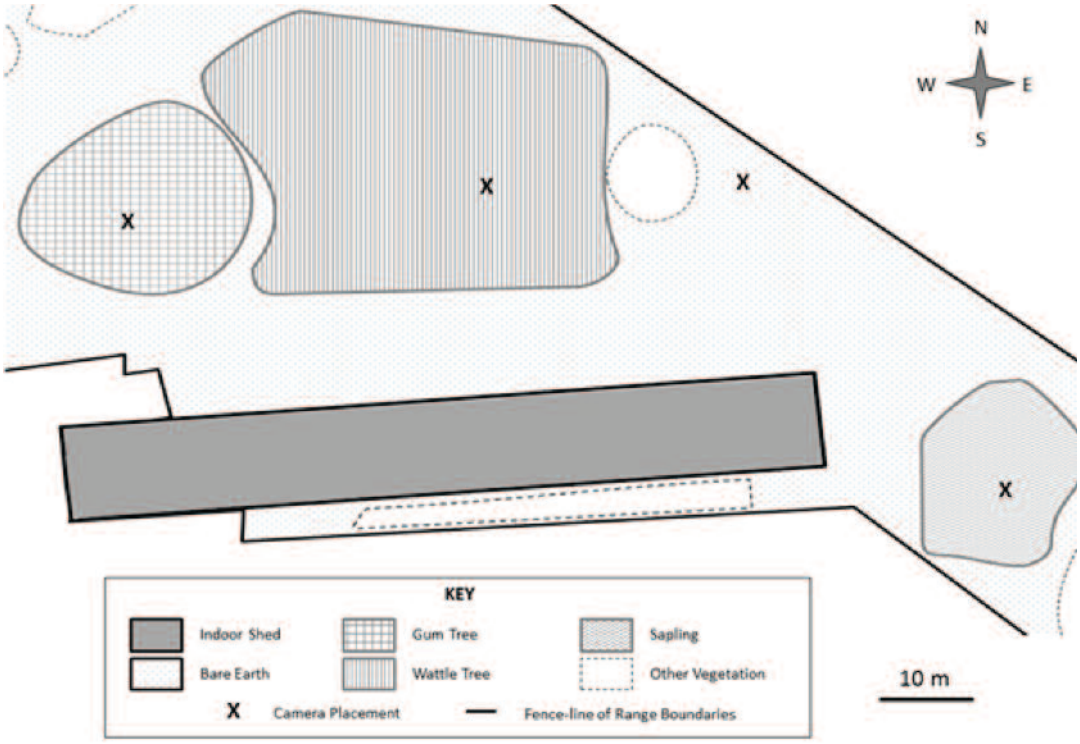
Keywords: *animal welfare, laying hen, natural behaviour, preference, range, shelter*

Introduction

Animal welfare is a term that is used to describe the quality of an animal's life (Bracke *et al* 1999), and natural behaviours may play a role in influencing animal welfare (Dawkins 2004). Natural behaviours can be defined as those that the wild counterparts to domestic or captive animals would display in their natural environment, as part of their behavioural repertoire. These behaviours have evolved through natural selection, and are therefore connected with survival, offspring production and growth (McFarland 1985 as cited in Duncan 1998). Behavioural observations are used as a tool to assess the welfare of animals, and researchers have proposed those animals that display natural behaviours in a captive environment compared to animals that do not, have better welfare (Waiblinger *et al* 2004). However, not all natural behaviours are indicative of good welfare (Dawkins 2004) and animals may be in a positive welfare state, but may have restricted access to perform natural behaviours (Fraser 2008). Hence, the context, species-specific attributes, physiological and fitness responses must be taken into account when assessing individual welfare states through behaviour. Additionally, the process of domestication led to qualitative rather than quantitative changes in behaviours, such as response thresholds to stimuli, between wild and domestic animals (Price 1999, 2002). The latter suggests that, while the magnitude of the behavioural responses to various stimuli may have been affected by domestication, most natural behaviours are conserved.

Domesticated chickens (*Gallus gallus domesticus*) that are used in free-range egg production are descended from the red jungle fowl (*Gallus gallus*) (Collias & Collias 1967; Fumihito *et al* 1994, 1996), and the green jungle fowl (*Gallus varius*) (Sawai *et al* 2010). Thus, these species are often considered as models for scientific studies investigating the behaviour and domestication of chickens (Dawkins 1989; Håkansson & Jensen 2004; Jensen 2006). Jungle fowl species are gregarious and territorial, with a hierarchical social structure. They exist on a diet that is easily provided by humans, which allowed for easy domestication and commercialisation of the species (Mignon-Grasteau *et al* 2005). In the wild, red jungle fowl are often found in areas with dense vegetation, such as bamboo forests or other tropical forests (Johnson 1963; McBride *et al*

Figure 1



Map of the outdoor range showing the different locations and placement of cameras. The outdoor range extended beyond the shown map, towards the top left and bottom right hand corners.

1969). Collias and collaborators (Collias & Collias 1967, 1996; Collias & Saichuae 1967) conducted observational studies on red jungle fowl in their natural environment and found that they rely upon clearings, whether natural or formed from agricultural land management, to move throughout their territories and forage. In the wild, the daily routine of the jungle fowl centres around the roost, with each bird having approximately 1 ha in which to roam, and consists of morning and evening foraging and resting in cover throughout the middle of the day (Collias & Collias 1967).

Outdoor ranges in modern commercial production, with large open spaces, very little shelter and rocky/gravel ground cover, are different from those more sheltered and diverse environments where their wild counterpart, the red jungle fowl, is found. Hens will utilise the outdoor area more when there is some form of cover, either artificial (domed tents: Hegelund *et al* 2006; mixed type: Gilani *et al* 2014; Larsen *et al* 2015; shelterbelts: Nagle & Glatz 2012) or natural (Nicol *et al* 2003; Gilani *et al* 2014), but differences in cover type preferences, and behaviour are often not explicitly reported or addressed. The occurrence of foraging, pecking, standing and walking on a commercial free-range farm differed between distinct areas with different vegetation and forms of enrichment within the range (Chielo *et al* 2016). However, these areas were also at increasing distance from the shed, confounding interpretation of the results based on either distance or environmental features, as a decreasing number of hens were found in the range further away from the shed. Artificial structural elements are used where natural habitats cannot be provided or are undesirable, but these designs are often based on very little information about hen preference and have varying levels of success in achieving the desired outcomes of encouraging greater numbers of hens to use the outdoor range or to range further away from the shed (Zeltner & Hirt 2003, 2008; Hegelund *et al* 2005; Nagle & Glatz 2012; Rault *et al* 2013). This may be due to a lack of understanding of the level of motivation or choice preference hens have for certain range elements and what additional behaviours the outdoor range can accommodate for domestic laying hens.

Several questions remain unanswered: what motivates hens to access the outdoor range, what behaviours do the hens perform while ranging, and how does this relate to different environments in the range?

The aim of this experiment was to determine the preference of free-range laying hens for distinct areas in the outdoor range, and the behaviours displayed in these areas, on one flock on a commercial farm. We also investigated the influence of time of day on the use of each area in terms of preference to access as well as behaviours performed. We hypothesised that hens would show a clear preference for features of the environment with dense vegetation resembling that of a tropical or bamboo forest with clearings to move throughout the vegetation to forage and socialise, mimicking the environment of the ancestral red jungle fowl. Additionally, we hypothesised that a greater diversity of behaviours would be performed in these highly preferred areas.

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Materials and methods

All methods used in this study were approved by the University of Melbourne Animal Ethics Committee (AEC project identification code: 1313042.1).

Study site and subjects

One flock of 8,000 Hy-Line brown laying hens was observed on a commercial free-range layer farm during summer in south-eastern Australia (January and February). The mean (± SEM) maximum and minimum temperatures were 32.8 (± 0.30) and 13.46 (± 0.23)°C, respectively, during the time of the study, recorded by the farm staff from on-site temperature loggers. Mean (± SEM) wind speed, recorded from the closest weather station, was 5.1 (± 1.1) km h^{-1} at 0900h and 7.1 (± 1.1) km h^{-1} at 1500h during the study period (Australian Bureau of Meteorology 2015).

The flock was 62 weeks of age at the start of the study and had access to the outdoor range from 22 weeks of age. The indoor shed measured 80 × 10 m (length × width), providing an indoor stocking density of ten hens per square metre, with a deep-litter (rice hulls) flooring system. Hens were provided with perches and nest-boxes indoors and had access to the outdoor range via pop holes on either side of the shed; pop holes measured 280 × 50 cm (width × height) and were spaced approximately every 6 m along both long sides of the shed, and through one larger barn door (approximately 8 m wide) open at the east end of the shed. Hens were fed *ad libitum* with a complete layer diet (Top Lay 210, Ripley Agriproducts Pty Ltd, St Arnaud, VIC, Australia) and had access to the outdoor range from just after sunrise until just prior to sunset from 0700 to 2100h during the data-collection period. Indoor temperatures were controlled only through natural ventilation. Maremma guard dogs were used to protect the hens from predators and were present in the outdoor range 24 h per day.

Range characteristics

The outdoor range for the flock was approximately 1.6 ha and contained varied vegetation and topography throughout. Distinct habitat types, hereafter referred to as 'locations', were broadly characterised based on their ground substrate and canopy cover in each range. Each location was 20 m from the indoor shed, had no obstructions in the path directly from the shed, but were of differing sizes (Figure 1).

Four distinct location types were identified (see Figure 2): 'Gum Tree' consisted of one large *Eucalyptus* spp gum tree with a 30-m high canopy cover; 'Wattle Tree' contained *Acacia* spp wattle trees that provided 1–2-m high dense canopy cover, as well as a misting sprinkler system that activated when outdoor temperatures rose beyond 30°C (this was not activated during the study); 'Bare Earth' consisted of bare sand and gravel ground with no canopy cover; and 'Sapling' consisted of self-propagated *Acacia* and Eucalyptus *spp* saplings with a bamboo-like dense (spacing of 10–40 cm between saplings, with a maximum canopy height of approximately 10 m) canopy structure.

Figure 2

The four distinct location types.

Data collection

Digital video sequences were collected using Scoutguard Zeroglow 10M cameras (Professional Trapping Supplies, Molendinar, QLD, Australia) positioned in each location. The field of view (FOV) for each location was 38 m^2, in a trapezoid shape. Cameras captured 10-s video sequences every 15 min during the hours of range access over 21 days. Data were then pooled into equal time-periods of the day for analysis: 0701–1030; 1031–1400; 1401–1730; and 1731–2100h. This was based on a clear diurnal pattern of range use, as seen by the number of hens in each area throughout the day.

One observer collated the behavioural data from the digital recordings using instantaneous point sampling (Martin *et al* 1993), wherein the number of hens in each location was counted and the behaviour of each hen present in that location recorded using a behavioural ethogram (Table 1) for each video recording. If the hen's behaviour was uncertain based on the first frame of the video, then the rest of the video (up to 10 s) was played to determine the first identifiable behaviour. If the behaviour of a hen could not be determined in the entire 10-s video, either because of obstruction by conspecifics or physical range features, then the hen's behaviour was recorded as 'unknown'.

Table 1 Ethogram for behavioural observations.

Behaviour	Description
Foraging	Pecks directed at the ground or trees, scratching at ground or walking with head below midline. Also includes pecks directed in the air presumably foraging for small insects
Preening	Grooming of plumage with beak in either sitting or standing posture
Social interaction	Any interaction, agonistic or not, with conspecific
Perching	Perching in or on tree or other structural element in the range
Vigilance behaviour	Sitting with hocks on ground, or standing, with neck outstretched, head upright and eyes open. Could be still or moving head around in alert manner
Resting	Sitting or standing in a resting non-vigilant state, head not outstretched and eyes open or closed
Lying	Head flat on ground or tucked under wing. Eyes open or closed. Body position flat on ground
Dustbathing	Lying with head rubbing on ground, scratching at ground, wings open and feathers ruffled
Locomotion	Moving at normal or fast speed (including wings flapping) to or from location/conspecific
Comfort behaviour	Head shake, wing stretch, wing flap or crop adjustment

Data analysis

A total of 31,659 hen behaviours, recorded on the range across all locations, were analysed for the study.

The average number of hens in each location at each time-point was calculated by pooling counts for each time-point within a time-period within each day. Behavioural data were based on the proportion of hens performing the behaviour at each time-period, which was then averaged over each day of data collection. Normality of data and homogeneity of variance residual plots were generated using the GLM function in Minitab (v17, Minitab Pty Ltd, Sydney, NSW, Australia) statistical software and assumptions of normality were considered met for most behaviours and total number of birds. Dustbathing and comfort behaviours did not meet assumptions of normality and were square-root transformed prior to analysis, after which they met the assumption of normality. Data are presented as least square means (± SEM). All data analyses were performed using SPSS statistical software (v22, IBM Corp, Armonk, NY, USA). To test for preferences of each location type, numeric data were analysed with a Linear Mixed Model using the REML method which included fixed effects of location (Gum Tree, Wattle Trees, Bare Earth and Saplings), time-period (0701–1030, 1031–1400, 1401–1730, 1731–2100h) and the interaction between location and time-period. Day (1–21) was included as a random factor and minimum and maximum outdoor temperatures, minimum and maximum shed temperatures, and wind speed at 0900 and 1500h were included as random factors nested within day. To test for differences in behaviour time budgets between time-points and location types for each type of behaviour, Linear Mixed Models, including the same fixed and random factors as above, were used. All *post hoc* multiple pair-wise comparison test *P*-values were adjusted using the False Discovery Rate (FDR) method as described in Verhoeven *et al* (2005), and only corrected values are shown. The relationship between the number of unknown behaviours observed and the number of hens present was tested using Pearson correlation.

Results

Number of hens in each location

There was a significant interaction between location and time on the number of hens observed ($F_{293.5}$ = 14.2; $P < 0.001$; Figure 3). The Wattle Tree location had more hens during morning (0701 to 1030h) and evening (1731 to 2100h) than any other location (FDR; $P = 0.03$). Both the Gum Tree and Wattle Tree locations had more hens in the midday period (1031 to 1400h) than the Bare Earth and Sapling locations (FDR; $P \leq 0.03$), and the Gum Tree location had more hens in the afternoon period (1400 to 1730h) than the Sapling location (FDR; $P \leq 0.03$). The combined number of hens in each location overall was influenced by time ($F_3 = 9.4$; $P < 0.001$) and dropped significantly in the afternoon and evening periods from the morning and midday periods ($P < 0.05$).

Behaviours within each location

The five most common behaviours seen across all locations were foraging (33.1 [± 1.3]%), locomotion (19.3 [± 1.2]%), preening (9.4 [± 0.8]%), resting (7.1 [± 0.5]%) and vigilance (6.1 [± 0.4]%; Figure 4). The time budgets of the least-performed behaviours within this flock are displayed in Table 2. There were significant interactions between location and time for the following behaviours: foraging ($F_{293.7}$ = 2.3; $P = 0.02$); preening ($F_{293.6}$ = 3.3; $P = 0.001$); resting ($F_{312.0}$ = 5.6; $P < 0.001$); vigilance ($F_{312.0}$ = 2.3; $P = 0.02$); social interactions ($F_{292.6}$ = 7.5; $P < 0.001$); and dustbathing ($F_{258.5}$ = 9.3; $P < 0.001$). Locomotory behaviours were influenced by location ($F_{308.6}$ = 33.2; $P < 0.001$) and time ($F_{308.7}$ = 4.4; $P < 0.01$), but not the interaction of location and time ($F_{308.7}$ = 1.2; $P = 0.30$).

Expression of behaviours within each location changed throughout the day (Figure 4, Table 2), with foraging and locomotion being more common in the morning and evening periods within most locations, and resting and preening behaviours being more common throughout the midday and afternoon periods. Vigilance behaviours remained fairly consistent throughout the day.

Comfort behaviours were influenced by location ($F_{260.2}$ = 12.0; $P < 0.001$) but not by time ($F_{261.9}$ = 1.2; $P = 0.31$) or the interaction between location and time ($F_{259.1}$ = 1.7; $P = 0.10$). Comfort behaviours were more prevalent in the Gum Tree and Wattle Tree locations than the Bare Earth (FDR; $P = 0.02$ and FDR; $P = 0.04$, respectively) and Sapling (FDR; $P = 0.03$ and FDR; $P = 0.05$, respectively) locations (Table 2).

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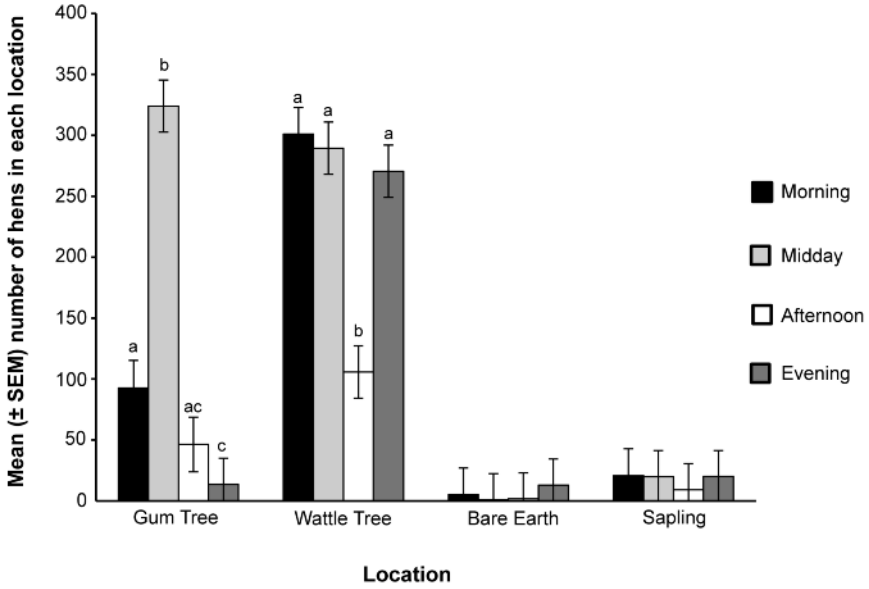
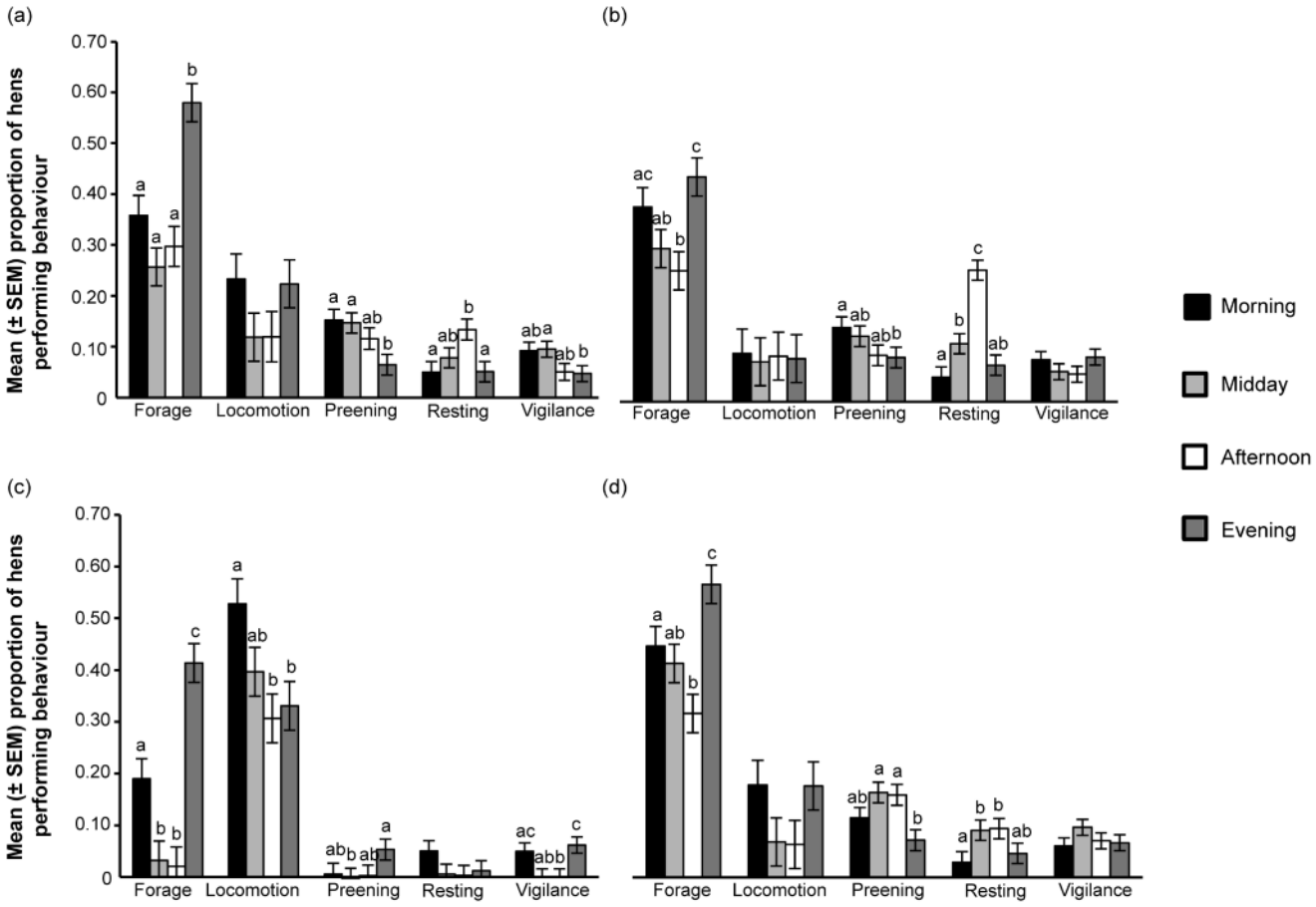
Figure 3



Mean (± SEM) number of hens per time-point in each location at four different time-periods: morning (0701–1030h); midday (1031–1400h); afternoon (1401–1730h); and evening (1731–2100h). Times within each location with different superscripts differ significantly (FDR; $P < 0.05$) from each other.

Figure 4



Daily time budget of hens in (a) Gum Tree, (b) Wattle Tree, (c) Bare Earth and (d) Sapling locations. Data shown are the mean (± SEM) proportion of hens per time-point performing each behaviour at the four different time-periods: morning (0701–1030h); midday (1031–1400h); afternoon (1401–1730h); and evening (1731–2100h). Behaviours at each location with different superscripts differ significantly (FDR; $P < 0.05$) over time.

Table 2 LSM (± SEM) proportion of hens performing the less-common behaviours (interaction, dustbathing, comfort behaviours and unknown behaviours) recorded in each of the study locations for each time-period.

Behaviour	Location	Time-period			
		Morning	Midday	Afternoon	Evening
Social interaction	Gum Tree	0.02 (± 0.004)[a]	0.04 (± 0.004)[b]	0.02 (± 0.004)[a]	0.00 (± 0.004)[c]
	Wattle Tree	0.03 (± 0.004)[a]	0.03 (± 0.004)[a]	0.01 (± 0.004)[b]	0.04 (± 0.004)[a]
	Bare Earth	0.00 (± 0.004)	0.00 (± 0.004)	0.00 (± 0.004)	0.00 (± 0.004)
	Sapling	0.00 (± 0.004)[a]	0.01 (± 0.004)[ab]	0.02 (± 0.004)[b]	0.00 (± 0.004)[a]
Dustbathing*	Gum Tree	0.00 (± 0.000)[ab]	0.00 (± 0.000)[ab]	0.00 (± 0.000)[a]	0.00 (± 0.000)[b]
	Wattle Tree	0.01 (± 0.000)[a]	0.07 (± 0.000)[b]	0.06 (± 0.000)[b]	0.01 (± 0.000)[a]
	Bare Earth	0.00 (± 0.000)	0.00 (± 0.001)	0.00 (± 0.001)	0.00 (± 0.000)
	Sapling	0.00 (± 0.000)	0.00 (± 0.000)	0.00 (± 0.000)	0.00 (± 0.000)
Comfort*	Gum Tree	0.01 (± 0.000)[ab]	0.02 (± 0.000)[a]	0.00 (± 0.000)[b]	0.00 (± 0.000)[b]
	Wattle Tree	0.02 (± 0.000)	0.01 (± 0.000)	0.01 (± 0.000)	0.01 (± 0.000)
	Bare Earth	0.00 (± 0.000)	0.00 (± 0.001)	0.00 (± 0.001)	0.00 (± 0.000)
	Sapling	0.00 (± 0.000)	0.00 (± 0.000)	0.00 (± 0.000)	0.00 (± 0.000)
Unknown	Gum Tree	0.07 (± 0.020)[a]	0.23 (± 0.019)[b]	0.24 (± 0.020)[b]	0.01 (± 0.019)[a]
	Wattle Tree	0.18 (± 0.020)[a]	0.18 (± 0.019)[a]	0.12 (± 0.019)[b]	0.15 (± 0.019)[ab]
	Bare Earth	0.00 (± 0.020)	0.00 (± 0.019)	0.00 (± 0.019)	0.01 (± 0.019)
	Sapling	0.10 (± 0.020)	0.08 (± 0.019)	0.06 (± 0.019)	0.04 (± 0.019)

Morning (0701–1030h), midday (1031–1400h), afternoon (1401–1730h), and evening (1731–2100h). LSM of behaviours with different superscripts differ significantly (FDR; $P < 0.05$) across time within each location.
* Indicates behaviours that did not meet assumption of normality, raw means are displayed.

In the morning, foraging and preening were reduced in the Bare Earth location compared to all other locations (FDR; $P \leq 0.03$), and hens interacted with conspecifics more in the Gum Tree and Wattle Tree locations than in the Bare Earth and Sapling locations during this period (FDR; $P \leq 0.02$).

In the midday period, the proportion of foraging was higher in the Gum Tree location than both Bare Earth (FDR; $P = 0.03$) and Sapling (FDR; $P = 0.02$) locations, and higher in the Wattle Tree compared to bare earth (FDR; $P = 0.04$). Preening, resting and vigilance were lower in the Bare Earth location compared to all other locations during the midday period (FDR; $P \leq 0.03$). Hens interacted with conspecifics more in the Gum Tree and Wattle locations than in the Bare Earth and Sapling locations during the midday period (FDR; $P \leq 0.02$), and dustbathing was more prevalent in the Wattle Tree location in this time-period than any other location (FDR; $P \leq 0.01$).

In the afternoon period, the proportion of foraging, preening, vigilance and interaction behaviours was lower in the Bare Earth location compared to all other locations (FDR; $P \leq 0.03$). During this period, significantly more hens performed preening behaviour in the Sapling location than the Wattle Tree location (FDR; $P = 0.01$). Resting increased during the afternoon in the Wattle Tree location compared to any other location (FDR; $P \leq 0.02$), and was more common in the Gum Tree and Sapling locations than the Bare Earth (FDR; $P = 0.02$) during this time. Dustbathing was more prevalent in the Wattle Tree location in this time-period than any other location (FDR; $P \leq 0.01$).

During the evening, the Gum Tree and Sapling locations had higher foraging than the Wattle Tree (FDR; $P = 0.03$ and FDR; $P = 0.01$, respectively) and Bare Earth locations (FDR; $P = 0.04$ and FDR; $P = 0.01$, respectively). Dustbathing and social interactions were more prevalent in the Wattle Tree location during the evening compared to all other locations (FDR; $P \leq 0.03$).

The number of 'unknown' behaviours was positively correlated with the number of hens in each observation time-point ($r = 0.55$; n = 329; $P < 0.001$).

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Discussion

Our results showed that hens within this flock had a preference for different locations in the outdoor range and this preference, as well as the behaviours hens performed in each of the locations, changed throughout the day.

Habitat preference

Laying hens exhibited preferences for different habitat types in the outdoor range, as demonstrated by the number of hens accessing each respective area, and this preference also varied throughout the day. The Wattle Tree location with dense, low canopy cover attracted more hens throughout most of the day than any other habitat type. Hen numbers in this location declined in the afternoon period, but remained higher than all other locations, suggesting that hens utilised another area of the range or the indoor shed during the afternoon. Indeed, the combined number of hens in all locations dropped in the afternoon and evening period, however as we did not assess the number of hens in the range and rather specifically assessed location use, we cannot determine whether fewer hens were in the range overall based on this result. The Gum Tree location, providing high canopy cover, was also highly attractive at midday, but was no more attractive to hens than areas of Bare Earth during other times of the day. The Sapling location with low dense canopy cover, but with less space between vegetation, was not preferred over the Bare Earth location at any time of the day. Taken together, these results suggest that hens prefer areas with good canopy cover and spacing between the vegetation.

The Gum Tree location may have been utilised most during the midday because the shadow cast by the gum tree was in greatest contrast to the light intensity on the ground that was in full sunlight. This provided shade and cover closest to the trunk itself and the hens clustered near the trunk. Shelter can provide hens with both protection from the sun as well as from predators, and both laying hens and jungle fowl are seen more in areas with shelter than without (Collias & Collias 1967; Hegelund *et al* 2006). When overhead cover is at least 1.5 m or taller, hens prefer types of shelter that provide not only overhead cover, but vertical cover as well (Larsen *et al* 2015). The Gum Tree, Wattle Tree and Sapling locations all provided this type of shelter, however in the gum tree location the horizontal cover was taller and the vertical cover smaller when compared to the Wattle Tree and Sapling locations, leaving this location more exposed overall. Nevertheless, more hens were likely to be observed in this area than in the Bare Earth area during the early morning and afternoon periods, but not in the evening. During the evening the shadow cast by the canopy cover extended far from the tree itself and was less intense, which possibly explained the lack of hens in this time-period as shade is highly influential for attracting hens to an area (Zeltner & Hirt 2008), and high contrast shade may contribute to the hens' perception of being protected from predators. It is unknown whether the hens would prefer the potential protection from aerial predators that structures provide over the cooling effect of shade as the two become more separated as the day progresses.

The Wattle Tree area was the only range feature specifically designed by the farmer to provide shelter for the hens; the trees were evenly distributed and had highly consistent canopy cover. The trunks of the wattle trees were 20–40 cm in diameter, spaced approximately 5 m apart and often branches were low enough for hens to perch on, or jump up to peck at leaves. The spacing of the tree trunks more closely mimicked what has been described as the natural habitats of the red jungle fowl, excluding the presence of an understory (Johnson 1963; Collias & Collias 1967; Collias & Saichuae 1967). Dustbathing, a plumage maintenance behaviour, was most commonly seen in this location possibly due to the abundance of dry, friable particulate matter on the ground in this well-covered area. An additional explanation for the hens' preference for this location could be that the placement of sprinklers here produced mist when temperatures rose above 30°C. Although sprinklers were not used during this study, a preference for this location in summer may have extended from previous experience.

It was expected that the Bare Earth location would not be attractive for laying hens due to the red jungle fowl's natural habitat consisting of areas containing a lot of dense and patchy vegetation (Johnson 1963; Collias & Saichuae 1967). Similar habitat preferences in the domestic chicken compared to the red jungle fowl are expected to be retained to some degree throughout the domestication process (Price 1984). More hens use the outdoor range in production systems where the range features some form of structure or cover than those that are barren (Bestman *et al* 2002; Bright & Joret 2012; Gilani *et al* 2014). Hens were more exposed to predators and different weather conditions in the Bare Earth area and the only ground cover was relatively barren, hence they spent more time moving and less time performing comfort behaviours, such as dustbathing and preening. The speed at which hens move throughout barren areas and the number of directional steps while foraging would be interesting to investigate in relation to proximity of cover and overall size of the barren area. If this location was in closer proximity to the other resources, more hens may utilise the area in a similar manner to red jungle fowl's use of clearings in forests for foraging and socialising (Johnson 1963; Collias & Collias 1967; Collias & Saichuae 1967).

The finding that the Sapling location was no more attractive than the Bare Earth location was unexpected, since it seemed to be more closely related to the habitat type of the red jungle fowl. One possible explanation for this is that the saplings were too densely grouped, which perhaps limited (or restricted) ease of ambulatory movement by the hens (Johnson 1963; Collias & Saichuae 1967). Additionally, this location was the only one on the east end of the shed (all others were located on the north side), and perhaps there were unknown differences in how the hens were accessing and utilising this side of the shed, which may have influenced how the different locations were utilised (ie sun exposure was too hot or bright to encourage hens to use this side of the shed or the wind was being channelled in an aversive way near this side). Within this study, it was not

possible to determine how the flock was distributed throughout the entire range, extending beyond each location, which might bring further understanding to why this location was not as attractive as other areas. Finally, the east side of the shed, although having large open doors, may have reduced access to the Sapling area for the majority of hens because that side of the shed is considerably shorter than the main length of the shed, thereby potentially restricting the number of hens exiting from that door and travelling to the Sapling area.

Determining the physical characteristics of the locations related to bird preferences and behaviour is difficult, particularly using on-farm observation techniques compared to experimental conditions. For example, it is difficult to determine if orientation, density or ground cover or an interaction of all these factors is related to preference and behaviour without performing a full factorial experimental design. However, it is clear that some locations were highly preferred and that this preference by laying hens and their behaviour in the locations change throughout the day. This could be related to sun orientation or different behavioural needs throughout the day, where some locations are better suited to meet these needs. Additionally, on a larger scale, seasonal changes have been shown to affect laying hen behaviour (Gilani *et al* 2014), however this study was performed only on one flock, and in the peak of summer when temperatures were relatively high. Further study is needed to determine how seasonal changes would affect area preference, particularly in other areas of the world, where shade may be less important, due to the lack of warmer weather experienced in Australia.

Behavioural time budgets

Overall, hens within the most highly preferred locations (Wattle Tree and Gum Tree) displayed a more diverse behavioural repertoire than in the least preferred areas. However, there was also a clear distinction between the two least preferred locations, where hens using the Sapling areas performed more varied behaviours than in the Bare Earth. Almost all behaviours recorded were influenced by location and/or time of day, as well as the interactions between the two.

Foraging in all locations, except in the Bare Earth area, was the predominant behaviour overall and each location showed an increase in the performance of foraging in either the morning or evening periods. This result is similar to that found by Larsen and Rault (2014), where foraging in and around a natural shrub structure increased in the evening compared to all other times of day, and was similar to the foraging behaviour observed in wild domestic fowl (Wood-Gush 1959; Savory *et al* 1978). Laying hens have been shown to increase feeding behaviour in both the mornings and evenings, with the greatest peak in the evenings, especially when hens are able to predict the onset of a dark period (Savory 1980). This evening peak is potentially due to a need to prevent a food deficit overnight, compensate for the energy requirements of oviposition or, more specifically, increase calcium uptake for shell formation. Interestingly, foraging in the evening was most prevalent in one of the least preferred locations (Saplings), which could possibly be explained by the presence of more leaf litter on the ground than in other areas. The additional leaf litter of the Sapling area compared to the dirt/gravel ground cover of the other three locations may also have provided a wider variety of food, or food that was rich in calcium. This study, however, was not able to determine whether foraging in each location was more rewarding either nutritionally or behaviourally. Foraging is considered a behavioural priority for laying hens (Weeks & Nicol 2006) and, therefore, providing varied and sheltered environments in the outdoor range may be the simplest way to allow for this natural behaviour.

Locomotory behaviours increased in the morning and evening periods in both the Gum Tree and Sapling locations, but did not change in the Wattle Tree location and decreased over the day in the Bare Earth location. It is likely that the hens used the morning and afternoon periods as a time of transition from the indoor shed to the outdoor range and *vice versa*, or perhaps to locations where foraging or other resources were better, which would be consistent with behaviours seen in the red jungle fowl in the wild (Collias & Collias 1996). As the Wattle Tree area was the most popular during the evening period, this could explain why fewer hens used this area for locomotion, which was also consistently lower throughout the day. The finding of decreased locomotion in the Bare Earth area during the afternoon and evening may be linked to the increase in foraging, which coincidentally included a lot of ambulatory movement. It is also possible that a decrease in bright overhead sunlight during the afternoon allowed hens to spend longer in the area, performing more time-consuming behaviours like foraging instead of locomotion, without being subject to extreme temperatures.

Resting occurred most commonly in the Wattle Tree location and was uncommon in the Bare Earth area, confirming that the presence of lower canopy cover is important for resting to occur. Resting also increased in the afternoon in the Wattle Tree location, which is a similar phenomenon to that seen in red jungle fowl and other flocks of laying hens (Larsen & Rault 2014). Preening was also uncommon in the Bare Earth location, but did show more diurnal variation in the Sapling location where there was an increase in the midday and afternoon periods.

Vigilance in all locations was relatively low compared to the other observed behaviours, especially in the Bare Earth area where hens did not linger. Vigilance in animals is generally decreased in larger groups (Roberts 1996) and further information on how inter-individual distances affected group size and vigilance within the context of these locations would be required to fully interpret these findings. Additionally, the presence of Maremma guard dogs could have reduced the vigilance behaviour in hens, as it is not uncommon for prey animals to use sentinels of other species to be alerted to predators (Zuberbühler 2000; Rainy *et al* 2004).

Overall comfort, social interaction and dustbathing behaviours were more prevalent in the Wattle Tree location; however, the number of hens performing these behaviours

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was relatively small compared to foraging, preening and locomotory behaviours. These behaviours are not frequently performed, but may still have important implications for overall well-being (Nicol 1987; Van Liere 1992).

Animal welfare implications and conclusion

Laying hens showed preference for different locations within the outdoor range, and this preference changed throughout the day as did the behavioural time budget of hens in each location. A greater behavioural repertoire was shown in the highly preferred areas, however, all behaviours were not shown equally at all times of the day in any one location. Locations with low dense canopy cover and shade were attractive to hens and may be enriching for the hens as well as instrumental in encouraging hens to explore further within the range; however, varied and complex environments throughout the entire range may be most effective factors for overall range design. Hen welfare in free-range productions can be promoted by providing hens with highly preferred environments and encouraging the performance of natural behaviours. This study examined the preference and behaviours of hens in one commercial flock during one season, thus results from this study cannot necessarily be extrapolated to other flocks of hens of different age, breed or season. Further research into how preference for different areas and performance of behaviours is influenced by seasonal changes or use of the indoor environment could lead to practical application of specific range design criteria on-farm to promote hen welfare.

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