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The welfare of long-line tethered and free-ranging horses kept on public grazing land in South Wales

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Abstract

A welfare assessment was conducted during 475 observations of 75 long-line tethered horses and 587 observations of 112 free-range horses kept on public grazing land in South Wales over a six-month period from March to August 2010. The observations included quantitative and qualitative behavioural assessments, assessments of physical welfare and assessments of the environment of the horse. Multi-level modelling was used to identify the significant factors affecting each measure. Tethered horses had similar behavioural repertoires to free-range horses but there were differences related to tethering, such as fewer observations of walking, trotting and cantering, increased vocalisations occurring during the observation and poorer qualitative 'mood' scores. There were few observations of severe physical welfare problems in either tethered or free-range horses, however tethered horses were observed more often to have eye abnormalities, hoof cracks, lameness and signs of limb pain but less often with mane and tail tangles, as thin or as dirty. Shelter from wind, rain or sun was available to almost all free-range horses (99.8% of observations) but was only found during 16.5% or fewer observations of tethered horses, giving them a greater risk of poor welfare during inclement weather. Similarly, tethered horses were infrequently observed to have access to clean water, and their willingness to drink when offered water, suggests the provision of water was inadequate and tethered horses may have been thirsty. There were significant confounding effects of the observer or climatic factors for some behavioural and physical measures that should be considered when conducting future studies.

Keywords: *animal welfare, behaviour, equine, health, legislation, tether*

Introduction

Horses are kept and managed in a variety of environments which may variably influence welfare, such as social contact (Harewood & McGowan 2005; VanDierendonck *et al* 2009), physical space (Jongman *et al* 2005; Chaplin & Gretgrix 2010), exercise (Houpt *et al* 2001; Freire *et al* 2009) and human interactions (Sondergaard & Halekoh 2003; Hausberger *et al* 2008). It is recognised that many aspects of horse welfare can be safeguarded in a range of management systems within the UK and that the most appropriate system will depend, among other factors, on the type and use of the horse (National Equine Welfare Council 2009). The management of horses is also likely to depend on the owners' access to resources, such as stabling or land. Although short-line tethering of horses in indoor stall housing systems occurs in a number of countries, this paper discusses the common form of tethering in the UK, where horses are restricted to an area of grazing land by means of a long-line tether. This tether is usually attached to a neck or head collar around the horse at one end, and a metal peg inserted into the ground at the other. There are no nationally collated data on the number of long-line tethered horses kept on grazing land in the UK. Preliminary observations in 2009 suggested that approximately 1,500 horses were kept on public grazing land in South Wales (Welsh Assembly Government 2011), of which it was estimated 120 were tethered (L Bishop, personal communication 2010). It is not known whether the situation in South Wales is representative of the rest of the UK, however tethered horses can be observed in many areas across the UK (S Mullan, personal observation 2012). Long-line tethering is also a common form of restraint for equines (eg Leeb *et al* 2003) and livestock such as goats (eg Jaitner *et al* 2001) in many countries around the world.

Long-line tethering of horses is permitted in UK law providing there is compliance with the Animal Welfare Act (2006). The National Equine Welfare Council produced a Code of Practice for Tethering Equines (National Equine Welfare Council 2006) and the devolved administrations within the UK have each produced a Code of Practice for the Welfare of Equines (eg Welsh Assembly Government 2008) that provides guidance on the suitability of animals for tethering, appropriate tethering sites, equipment and the management of tethered horses. Tethering of horses is an

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emotive subject within the UK, probably partly because they are often visible to members of the public. The tethering of horses and ponies is covered within the 'frequently asked questions' section of the RSPCA website where they state that they are 'not in favour of tethering' and that 'tethering is not suitable for the long-term management of an animal' due to the physical restriction and increased risk of poor welfare caused by tethering (RSPCA 2011). When the UK Government consulted on a new piece of overarching animal welfare legislation it asked about a number of welfare issues across a range of species. Eighteen people responded to the question of whether tethering of horses should be banned under the proposed legislation and 12 (66.6%) were in favour of a ban (Defra 2002). Tethered horses are also commonly at the centre of equine welfare complaints to Cardiff Trading Standards (L Bishop, personal communication 2010).

This study aimed to compare the effect of long-line tethering on the physical and mental welfare of horses with that of free-ranging horses in similar grazing locations. It also aimed to assess the compliance with the Code of Practice relating to tethering (Welsh Assembly Government 2008) and derive evidence for future recommendations.

Materials and methods

Welfare Assessment Protocol (WAP)

Welfare assessments of individually identified long-line tethered and free-range horses were made over a six-month period from March to August 2010 by one observer (JH). The populations of tethered horses in the study were chosen from four areas of common grazing land with public access previously identified as usually having tethered horses on them. All tethered horses present on the sites were assessed. Six populations of free-range horses on common land, three of which were on the same commons as the tethered horses, were used to provide comparison data for the tethered horses and attempts were made to match the type of horse, overall common size and proximity to houses with the tethered populations. The free-ranging horses observed in the study were chosen at random from the free-range populations on the first visit to each site. Between five and 27 visits were made to each location with the mean number of days between visits varying from 5.3 to 16.4 days for the locations. Photographic and written descriptions ensured that all study horses could be individually identified on future visits. The history and life of the horses when not observed was not known.

The welfare assessment protocol designed for this study drew on published equine welfare assessments (Ashley *et al* 2005; Pritchard *et al* 2005) and other literature (Morel *et al* 2006) for some measures. It combines the use of animal-based direct assessments where possible with welfare inputs to cover aspects that would be difficult to assess through animal observations alone. The assessments made are described in Table 1. In addition, assessments were made that could check adherence to animal welfare legislation (Animal Welfare Act 2006) and the Code of Practice for the Welfare of Equines (Welsh Assembly Government 2008). The order of assessment of each horse was as follows: quantitative behavioural observation, qualitative behavioural observation, individual description, physical health assessment, drink test, availability of feed and water, and an assessment of the environment of the horse, items on the horse and management of the horse. Finally, for tethered horses, it was noted at the end of the assessment if they had become entangled in the tether during the observation.

Statistical analysis

Analysis of the data to compare the study populations of tethered and free-ranging horses was carried out using the statistical packages SPSS vs18 and MLWiN vs2.21 (Rasbash *et al* 2004).The qualitative behavioural assessments were analysed using Principal Component Analysis (PCA, covariance matrix without rotation). Principal Component Analysis transforms data consisting of a range of variables, which may correlate, into a smaller number of uncorrelated variables, termed 'principal components' (Shaw 2003).

The data are presented at the level of 'observation' rather than 'horse' to capture the variability that exists between observations within the same horse. Comparison between the data presented and the descriptive data at the level of 'horse', by only using data from the first observation of each horse, rather than 'observation', showed different levels of intra-horse variability across the measures. Therefore, it was concluded that it would be more useful to present all of the data observed over a number of months to give a greater indication of welfare over the observation time-period.

However, when trying to determine valid associations between measures, multi-level modelling was used to account for repeated observations within horses and other factors, such as location of the horse.

The effects of tethering and other environmental and management inputs on the different welfare outcomes were fitted using three different types of multi-level model depending on the welfare outcomes considered. For the two continuous outcomes ('number of vocalisations' and 'number of playfulness bouts') and the PCA components, normal models were fitted with three levels of classifications — visit, horse and location — representing the hierarchical structure of the data: visits being nested within horses within locations. For two quantitative behaviours ('lying' and 'stand not alert'), the human-animal interaction variables and the physical health measurements, binary models were fitted with the same three levels of classifications (visit, horse and location), on whether the behaviours or the health indicators were observed during the observation period. Finally, for scan-sampled quantitative behaviour assessment outcomes (except 'lying', 'stand not alert', 'number of vocalisations' and 'number of playfulness bouts'), binomial models were fitted using the number of times during the scan sample (out of 20) when the behaviour was observed, with 20 used as denominator. For these models, a four-level structure was used to allow for variations to occur at the observation (visit) level, the horse level and the location level. Estimation of the variation at

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Table 1 The methods used to assess the welfare of the horses.

Type of assessment	Method of assessment
Quantitative behavioural observations	Scan sample every 30 s for 10 min. Behavioural categories: standing alert (eyelids fully open), standing not alert (eyelids not fully open), standing swishing tail (vigorously), walking, trotting, cantering/galloping, grazing, eating (not grazing), drinking, lying down, mutual grooming, other friendly social interactions (between horses), antagonistic social interactions (between horses, where at least one horse appeared negatively affected), defaecation/urination, other behaviours. Number of vocalisations and playfulness bouts in 10 mins
Qualitative behavioural observations	Record a score for the following terms on a visual analogue scale following 10-min quantitative behavioural assessment: inquisitive, anxious, nervous, alert, content, miserable, excited, relaxed, interested, active, resigned, bold, sociable, niggling, scared, grumpy, calm (after methodology described in Wemelsfelder *et al* 2000)
Approach test (after Burn *et al* 2010)	Response to the approach of an observer from 2 m in front, but slightly to the side, of the horse (moves head away, moves head towards, moved body away, moves body towards, no movement, aggressive)
	Response to the attempt to touch the horse under the chin (moves head away, moves head towards, moved body away, moves body towards, no movement, aggressive)
	Closest distance of observer to the horse, do ears follow the observer
Other behavioural observations*	Drink test (offer half-full bucket of water for 5 min, record whether horse drinks none, some, most or all the water)
	Entanglement in the tether during observations (did the horse become entangled in the tether during any part of the observations)
Signalment	Sex, type, age (assessed by dental observation and other features [< 2.5 years, 2.5–20 years, > 20 years]), obviously pregnant, nursing mare
Physical health assessments	Eye abnormalities (watery discharge, mucopurulent discharge, corneal abnormality, lens abnormality, other)
	Body lesions > 2 × 2 cm or > 1 × 4 cm (superficial: pink/hairless skin; skin broken: visible pink/red skin tissue visible; deep tissue: visible muscle, tendon or bone)
	Body condition score (six-point scale [National Equine Welfare Council 2003])
	Vertical hoof cracks (record whether from top or bottom: < 1/3, 1/3–2/3, > 2/3, full hoof length)
	Horizontal hoof cracks originating > 1 cm from ground (< 1/3, 1/3–2/3, > 2/3 hoof circumference)
	Abnormal hoof conformation (abnormal hoof-pastern axis, abnormal left-right balance)
	Long toes (hoof wall at the toe > 3× hoof wall at heel)
	Abnormal hoof quality (wavy, divergent or deep [> 3 mm] rings in hoof)
	Limb dirtiness above hoof: continuous dirt (up to fetlock, fetlock to mid-cannon, mid cannon to knee/hock, above knee/hock
	Signs of mud fever (scabs, crusting, cracking, bristled hair in the pastern area)
	Dirt on body: diameter of largest patch (handprint [18 cm], forearm [40 cm], arm [70 cm] > 70 cm)
	Poor coat condition of the neck (scurfy, matted)
	Moulting tags (tags of matted hair hanging from horse)
	Mane or tail tangles (record whether mane or tail, < 1/3, 1/3–2/3, > 2/3 affected)
	Skin parasites (lice, ticks)
	Faecal staining (on hind limbs)
	Lameness (obvious lack of weight-bearing whilst standing and/or lame when walking)
	Signs of limb pain (weight shifting, toe pointing, foot lifting)
	Sick or disabled
	Lesions associated with headcollar/neckstrap (observe under material)
Feed and water	Percentage of site containing grassland, percentage grassland containing weeds, percentage grassland covered by faeces, typical grass length (cm), clean water available, supplementary feed present (type), ragwort accessible to horse
Environment of the horse	Weather during observation (sun-shadow present, rain, wind > force 5 [small trees swaying]), shelter from sun, shelter from rain, shelter from strong wind, dry ground available, uneven ground*, sloping ground*, free-roaming horses in the location*, free-roaming horses entered tether site*, objects present that could ensnare tether*, area available, road through site**
Items on the horse	Wearing rug, presence and material of headcollar, neckstrap, limb tether*, tether length*, tether material*, swivel at horse end*, swivel at ground end*, tether < 4 cm from another tether end*
Management practices	Exercise off tether each day*, inspection at least every 6 h*, changed tether site at least every 24 h*, inspection at least every 24 h**, measures taken to alleviate a lesion associated with a headcollar/neckstrap, horse clearly identified*

* Only tethered horses assessed in this measure; ** Only free-range horses assessed in this measure.

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Table 2 The signalment of the study populations of tethered and free-range horses.

		Tethered horses	Horses (n)	Free-range horses	Horses (n)
Total number of horses observed		70 + 5 free-range during some observations		107 + 5 tethered during some observations	
Age	< 2.5 years	23.5%	67	9.3%	108
	2.5 to 20 years	73.5%		88.9%	
	> 20 years	1.5%		1.9%	
Sex	Female	38.2%	70	77.8%	112
	Female with foal	10.0%		22.3%	
	Male	61.8%		22.2%	
	% of male, geldings	63.6%		82.1%	
	% of male, stallions	36.4%		10.7%	
Type	Welsh pony	30.9%	68	63.0%	108
	Cob	61.8%		31.5%	
	Shetland	5.9%		3.7%	
	Thoroughbred type	1.5%		1.9%	
Total number of observations		475	75	587	112
Number of observations per horse	Range	1–29	75	1–19	112
	Mean	6.2		5.3	

the observation (visit) level was done by replicating the visit level twice — thus assuming the structure of the data is visit within visit, within horse within location. The duplication of the first level (visit) allows variation at the observation level to be quantified, as binomial distributions assume that the variation at the observation level (level 1) is directly proportional to the mean of the data, and thus cannot be explicitly estimated as part of the model-fitting process. The multilevel structure allows variation in the data to be partitioned between the visit, horse and location, and measures specific to the different levels (ie visit, horse or location specific variables) to be considered alongside each other and predict behaviours which are observed at the time of the visit (and may differ from visit-to-visit, even within the same horse).

For each welfare outcome, univariable models were fitted initially where each environmental and management input was tested, one at a time, for the effect on the outcome variables. All the inputs, which were found to be significant, were added together into a multivariable model, and the model refitted to check for significance of each variable in this combined model. Input variables which lost significance were removed one at a time, starting with the least significant, until all the variables remaining in the model were significant.

Finally, the scan samples were tested to establish whether using data collected in the first or the last 5 min would yield the same models as using the complete 10 min of data. This was done by refitting the best models obtained using the whole 10-min scan results on the two subsets of the data corresponding to the observations made during the first and the last 5 min.

Results

Study population

The numbers of horses and observations conducted are shown in Table 2 along with the data relating to the signalment of the study populations. There were significant differences in sex, age and type of tethered and free-range horses assessed (Chi-squared test, $P < 0.001$, $P = 0.030$, $P < 0.001$, respectively between the two groups) but no significant difference in the number of observations made per horse between the two groups (Mann-Whitney *U*-test, $P = 0.894$).

Behavioural observations

The results of quantitative behavioural observations of 475 tethered and 587 free-range horse observations are shown in Figure 1. The most frequently observed behaviour during the 10 min of scan sampling at 30-s intervals was 'grazing' (61.2% for tethered horse observations and 56.5% for free-range horse observations). Other behaviours not represented in Figure 1 each accounted for less than 0.5% of scan samples of both tethered and free-range horse observations. Antagonistic interactions were rarely observed during tethered and free-range horse observations (0.1% each). The significant input variables for each of the behaviour output variables are shown in Table 3 (available at the supplementary material to papers published in *Animal Welfare* section at the UFAW website, www.ufaw.org.uk). To interpret the table the intercept value represents the baseline value in the model but is not relevant in itself. The direction and magnitude of the

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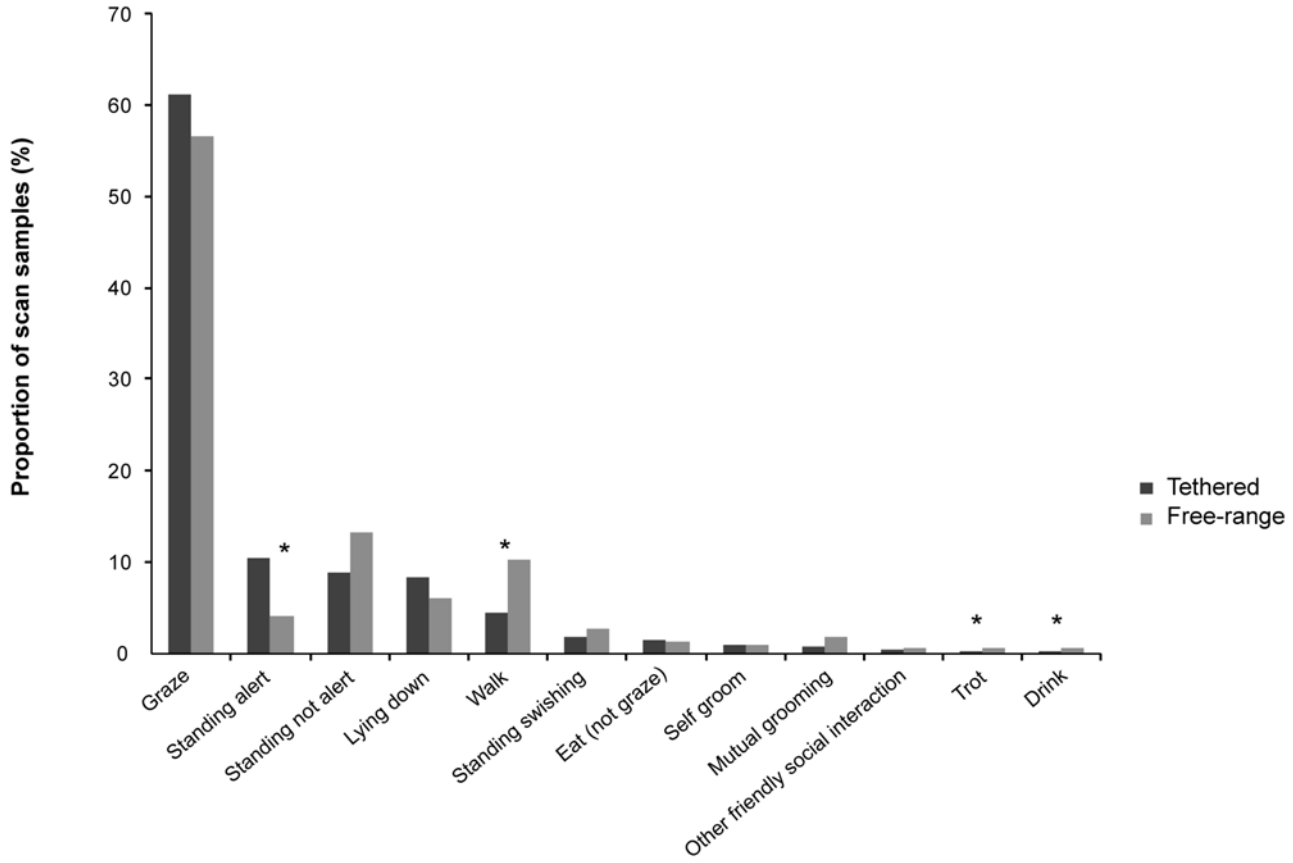
Figure 1



The proportion of scan samples tethered horses (n = 475 observations) and free-range horses (n = 587 observations) spent performing each behaviour. Behaviours representing less than 0.5% of scan samples of both tethered and free-range horses are not shown.
* Tethering was a significant factor in the models explaining the differences between the data relating to tethered and free-range horses.

effect can be understood from the parameter estimates. For example, in Table 3, it can be seen that, all other things being equal, free-ranging horses were 3.7 times more likely to be observed at 'trot' than tethered horses. Likewise, free-ranging horses were 2.75 times more likely to be observed at 'walk' than tethered horses and, secondly, that all other things being equal (for example, irrespective of whether horses were tethered or free-ranging), horses < 2.5 years of age were 1.62 times more likely to be observed at 'walk' than horses 2.5 years or older. The behaviours where tethering was a significant explanatory factor were 'standing alert', 'walking', 'trotting', 'cantering' and 'drinking' (see Table 3). Horses less than 2.5 years old were more likely to be observed 'lying down', 'walking' and engaging in 'other friendly social interactions' and less likely to be observed 'standing not alert' and 'eating (not grazing)'. Climatic conditions affected the likelihood of observing standing, lying and eating behaviours. Vocalisations during the 10-min behavioural assessment occurred in 11.7% of tethered horse observations and 2.5% of free-range horse observations. Tethered horses vocalised significantly more than free-ranging horses, and horses observed when wind speed was greater than force 5 vocalised more than those observed when the wind was lighter (see Table 4 [available at the supplementary material to papers published in *Animal Welfare* section at the UFAW website, www.ufaw.org.uk]). Exhibitions of playfulness were observed during 1.9% of tethered horse observations and 0.5% of free-range horse observations; however, the age of the horse was the only significant factor explaining the data, with more playfulness being observed in horses less than two and a half years old (see Table 4).

A comparison of the statistical models produced when analysing the full 10 min of the behavioural observations, compared with the first and second 5 mins independently, showed that significant factors in each of these three statistical models were the same for a few behaviours ('standing alert', 'standing swishing tail' and 'drinking') but different for the majority of behaviours (walking, trotting, cantering, grazing, eating [not grazing], self grooming, mutual grooming, other friendly social interactions, antagonistic interactions).

The response to the approach of an observer is shown in Figure 2. When approaching tethered horses on the majority of occasions they did not move their head or body either

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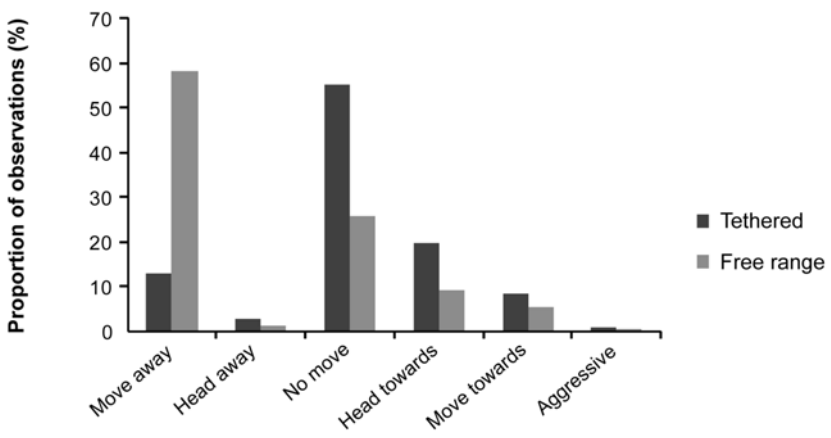
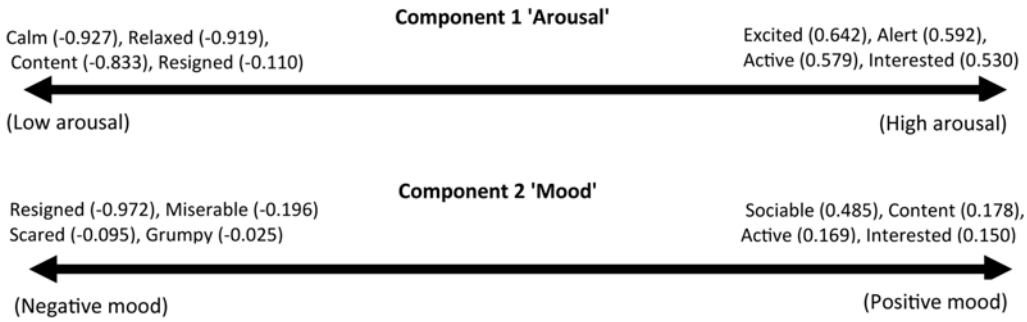
Figure 2



The response of tethered and free-range horses to the approach of the observer (n = 466 tethered horse observations, n = 554 free-range horse observations).

Figure 3



The most influential terms for components 1 (Arousal) and 2 (Mood) derived from PCA of a qualitative behavioural assessment during 469 observations of tethered horses and 578 observations of free-range horses.

towards or away from the observer (55.4%, n = 466 observations) whereas in observations of free-range horses the majority of times the horse moved away from the approaching observer (58.1%, n = 554 observations). The observer was able to touch the tethered horses during 82.2% of assessments (n = 467 observations) and free-range horses during 34.2% of assessments (n = 561 observations). The significant variables included in the models to explain the data relating to the approach of an observer are shown in Table 3. Tethering was a significant factor in explaining the combined data relating to horses which moved their head and/or body towards the observer and head and/or body away from the observer on approach. When supplementary feed was present horses were more likely to move their head/body either towards or away from the approaching observer, track the observer with their ears and move their head/body towards the observer when attempting chin contact.

Principal Component Analysis of the qualitative behavioural data resulted in four main components being produced before the angle of the line on the screen plot changed substantially. However, analysis of the loadings of terms on these components indicated that only the first two components, explaining 68.1% of the variance in the data, were useful. Component one is named 'Arousal' and denotes the level of activity and mental arousal of the horse. Component two is named 'Mood' and denotes the subjective experience of the horse. Both of these components are represented pictorially in Figure 3, showing the four terms whose scores most influence each end of the component and their loadings on that component.

The mean score for component 1 (Arousal) was 2.07 for observations of tethered horses and 0.80 for free-range horses. The mean score for component 2 (Mood) was 0.36 for observations of tethered horses and 0.53 for free-range horses. Tethering was a positive significant factor in explaining the mood scores ascribed to horse observations but was not a significant factor for the arousal scores (see Table 4). Analysis of the relationship between the quantitative behavioural scan data and PCA components 1 and 2 showed that component 1 'Arousal' had eight significant behaviours associated with it, whereas component 2 'Mood' only had 'standing not alert' as a significant factor in the model.

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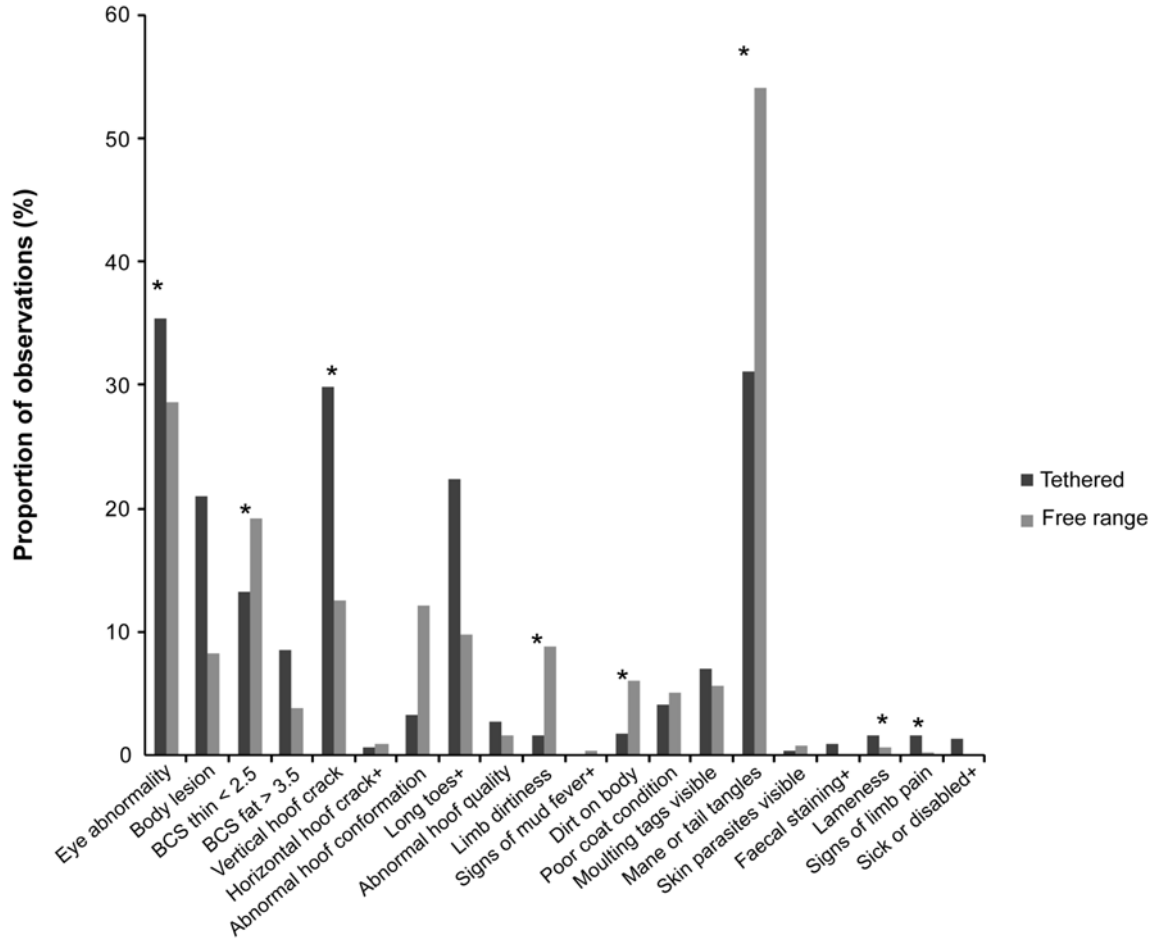
Figure 4



The physical health assessments recorded during observations of tethered and free-range horses (n = 242–475 observations for tethered and n = 146–587 observations for free-range horses).
* Tethering was a significant factor in explaining the differences between the data relating to tethered and free range horses; + statistical models were unable to be run for this measure.

Physical health measures

The results of the physical health assessments are shown in Figure 4. The most frequent occurrences for observations of tethered horses were for eye abnormalities (35.4% of observations), mane or tail tangles (31.1% of observations) and vertical hoof cracks (29.9% of observations). Similarly, observations of free-range horses showed frequent occurrences of mane and tail tangles (54.2% of observations) and eye abnormalities (28.7% of observations) but a body condition score of less than 2.5 (thin) was the third most common condition observed in these horses at 19.2% of observations. The significant factors included in the models to explain the physical health data are shown in Table 5 (available at the supplementary material to papers published in *Animal Welfare* section at the UFAW website, www.ufaw.org.uk). Tethering was a significant factor linked with more frequent observations of eye abnormalities, vertical hoof cracks, lameness and limb pain for tethered as opposed to free-range horse observations. In contrast, tethering was a significant protective factor associated with fewer observations of mane and tail tangles, body and limb dirtiness and being thin (body condition score < 2.5) observed in tethered as compared to free-range horse observations. The minimum distance the observer could get from the horse was a significant factor in explaining some variables, with closer distances being associated with more eye abnormalities, body lesions, ectoparasites, lameness and signs of limb pain being recorded. The meteorological conditions at the time of the observations also significantly affected the probability of observing most of the conditions.

The more severe end of the spectrum of the welfare measures were observed less frequently during both tethered and free-range horse observations and are shown in Table 6. The following conditions were never observed in either tethered or free-range horses: corneal or lens eye abnormalities, body lesions extending into tissue below the skin and body condition score 5 (very fat).

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Table 6 The more severe welfare problems recorded during observations of tethered and free-range horses.

	Proportion of observations of tethered horses (n = 242–475)	Proportion of observations of free-range horses (n = 146–587)
Watery eye discharge	19.4%	22.5%
Mucopurulent eye discharge	16.0%	6.1%
Corneal abnormalities	0%	0%
Lens abnormality (cataract)	0%	0%
Full thickness skin lesion	2.5%	0.2%
Body lesion extending into tissue deeper than the skin	0%	0%
Body condition score 1 (very thin)	0.4%	0%
Body condition score 5 (very fat)	0%	0%
Vertical crack more than 1/3 of the length of the hoof but not full length	11.0%	0.3%
Full length vertical hoof crack	1.3%	0.3%
Horizontal crack more than 1/3 of the length of the hoof	0%	0.3%
Dirt on the limb extending above mid-cannon	0.4%	1.3%
Largest patch of dirt on the body is greater than 40 cm	0.4%	0.2%

Resource-based assessments

More tethered horses (n = 469 observations) were recorded with a neckstrap (69.9% of observations) than a headcollar (38.6% of observations) although the reverse was true for free-range horses (n = 558 observations) which were wearing a headcollar in 6.3% of observations and rarely observed with a neckstrap (1.6% of observations). Limb tethers were not observed.

Webbing was the most common material for headcollars or neckstraps (61.4 and 7.1% of observations of tethered and free-range horses, respectively), followed by rope (28.8 and 0.0% of observations of tethered and free-range horses, respectively) and then leather (15.2 and 0.5% of observations of tethered and free-range horses, respectively). Lesions were associated with the material contacting the horse in 2.9% of observations of tethered horses (12 observations, n = 415), with evidence of measures taken to alleviate the lesion in one observation, and four out of 25 observations of free-range horses (16%), of which none had any measures taken to alleviate them. In statistical models, using the data from tethered horses only, these lesions were positively associated with headcollars and negatively associated with neckstraps (see Table 7). The type of material had no effect on the presence of these lesions.

Horses were rarely observed wearing a rug (0 and 0.2% of observations of free-range and tethered horses, respectively). No horses were clearly identified externally.

The environment of the horse

During almost all observations of free-range horses they had access to shelter from wind, rain and sun (99.8% of observations, n = 559). Tethered horses were infrequently observed with shelter from wind (16.5% of observations, n = 470), rain (14.3% of observations, n = 469) and sun (12.7% of observations, n = 471). The significant explanatory variables for the environment of tethered horses are shown in Table 7. Tethered horses were more likely to be observed with access to shade in higher temperatures and likewise to be observed with access to wind shelter when there was a strong wind (greater than force 5). Access to water was less frequently observed for tethered than free-range horses (10.4%, n = 470 compared with 97.6%, n = 550 of observations, respectively). When water was provided for tethered horses it was nearly always in a bucket (94% of observations of water sources) and mostly clean (86.4% of observations of water sources). The provision of water to tethered horses was not associated with any climatic or other factors in a statistical model. Free-range horses were mostly observed to have a stream as their water source (96% of observations of water sources) and their water was nearly always clean (97.2% of observations of water sources). Tethered horses were more frequently observed with supplementary feed (4.5% of observations, n = 465) than free-range horses (0.5% of observations, n = 561). The presence of supplementary feed for tethered horses was positively associated with observations of tether sites where more than 30% of their grassland was estimated to be weeds. Tethering was a significant factor in the models for the presence of supplementary feed (see Table 7), water and shelter (data not shown) during observations.

The mean grass length was the same in 468 observations of tethered and 561 observations of free-range horses (21 mm) and high proportions of the sites of tethered and free-range

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Table 7 The significant variables explaining data relating to the tether site, equipment or horse behaviour derived from up to 475 observations of tethered horses.

Output variable	Odds ratio of input variables (boundaries of 95% confidence interval)							
	Intercept	Neckstrap	Headcollar	°C during observation	Wind > f5 during observation	Tree present	Water present	> 30% of the grassland on the tether site is weeds
Lesion associated with items on the horse*	0.07 (0.04–0.15)	0.19 (0.06–0.65)						
Lesion associated with items on the horse*	0.02 (0.01–0.04)		3.71 (1.10–12.54)					
Horse became entangled in the tether during observation	0.13 (0.07–0.25)					3.28 (1.37–7.83)		
Drink water when offered in drink test	3.21 (2.28–4.51)						0.12 (0.03–0.46)	
Tethered in a site with access to shade	0.01 (0.00–0.08)			1.13 (1.04–1.23)				
Tethered in a site with access to shelter from the rain	0.02 (0.00–0.10)			1.12 (1.03–1.21)				
Tethered in a site with access to shelter from wind	0.03 (0.01–0.16)			1.09 (1.01–1.18)	2.41 (1.03–5.64)			
Any type of supplementary feed present	1.65 (0.18–15.46)			0.79 (0.69–0.90)				4.54 (1.27–16.30)

Blank cells indicate the input variable was not significant in the model to explain the data relating to that output variable.
* The model had to be run separately for the presence of a headcollar or neckstrap.

horses were grassland (96.9 and 99.6% of observations, respectively). The grassland was estimated to contain more than 30% weeds in 10.9% of observations of tethered horses and 49.9% of observations of free-range horses. The mean estimate of the coverage of the site by faeces was 4.6% for observations of tethered horses and 5% for observations of free-range horses. Faecal worms were visible in faeces in 0.7% of observations of tethered horses (n = 420) and never in observations of free-range horses (n = 193). During 36% of observations tethered horses had access to ragwort (*Senecio jacobaea*) (n = 470) as compared to 5.2% of observations of free-range horses (n = 524). Dry ground for lying was always observed to be available to both tethered and free-range horses.

Assessments specific to tethered or free-range horses

There was a range in tether lengths, types and compliance with aspects of the welfare code on tethering (Welsh Assembly Government 2008) as shown in Table 8. In a statistical model the likelihood of becoming entangled in the tether during the observation was not found to be associated with the presence of a swivel at either the horse or ground end but was associated with one factor, the presence of a tree at the tether site (see Table 7). Almost three-quarters of the times when tethered horses were offered a bucket of water by the observer they drank at least some of it (see Table 8). The only factor that affected whether tethered horses drank or not was whether the horses were observed with access to water. Those that already had access to water were less likely to drink in the test (see Table 7).

Discussion

The large number of observations of, and the use of multilevel statistical modelling to account for the differences between, tethered and free-range horses, provide a high level of confidence in the results produced. Repeated observations of most horses gave an indication of their welfare over time but the effect of the variable number of observations of horses on the descriptive results is not known. It is also not clear how the results of this study would compare with observations of the same horses over a different time-period, for example, autumn and winter, or with horses in other locations. The differences between age, sex and type of the study populations of tethered and free-range horses may relate to factors specific to the study locations or may indicate a wider difference in the management of horses. For example, rather than have high value breeding stallions free ranging on open land it may be more common in general to tether them to enable closer management of them and protect them from road traffic accidents.

Despite a number of methodological differences, the behavioural data of both tethered and free-range horses concur with other studies investigating wild or feral horse

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Table 8 Assessments specific to tethered (n = 187–471 observations) or free-range horses (n = 132–559 observations) including elements designed to assess compliance with the welfare code (Welsh Assembly Government 2008).

Assessments of tethered horses			**Number of observations**
Mean length of tether (m)		16.7 m (range 4–35 m)	468
Mean area available (m^2)		105 m^2 (range 18–220 m^2)	470
		Proportion of observations	
Tether < 6m in length (19.7 feet)		0.9%	
Tether > 8 m in length (26.2 feet)		95.7%	
Tether material (more than one type possible)	Rope	42.3%	
	Webbing	1.5%	471
	Chain	57.5%	
Swivel at horse end		10.7%	469
Swivel at ground end		7.3%	468
Slip knot at neck		0.0%	
Tether end < 4 m from another tether end		4.7%	469
Objects that could ensnare tether		8.9%	463
Entanglement in tether during observation		9.8%	470
Free-roaming horses in the location		56.9%	466
Free-roaming horses entered tethered site		14.9%	471
Drinks water when offered in bucket by observer		73.2%	198
Level site		22.0%	
Uneven ground		44.0%	468
Sloping ground		52.8%	
Exercise off the tether each day (direct observations or owner reports)	No	4.8%	
	Yes	2.7%	187
	No evidence	92.5%	
Inspection at least every 6 h (direct observations)	No	1.2%	
	Yes	32.8%	244
	No evidence	66.0%	
Changed tether site at least every 24 h (proxy measures such as the amount of faeces in the area and grass length in the tether site compared to the surrounding grass)	No	1.8%	
	Yes	80%	451
	No evidence	18.2%	
Assessments of free-range horses			
Tethered horses present in site		2.5%	559
Inspection < 24 h	No	4.5%	132
	Yes	21.2%	132
	No evidence	74.2%	132
Road through site		33.3%	6 sites*

* Five free-range sites + one tether site where horses were sometimes observed free ranging.

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behaviour where grazing accounts for the majority of the time budget and smaller but significant contributions are made by walking and standing (Duncan 1980; Lamoot & Hoffmann 2004; Morel *et al* 2006). The reduction in walking, trotting and cantering and the increase in standing when alert observed in tethered horses suggest that there is a shift from active to inactive behaviours in tethered horses when compared to free-range horses. The likely cause of these changes in behaviour is the physical restriction resulting from the tether. Other systems for keeping horses, such as stabling, also restrict a horse's movement but it is not known how these different types of physical restriction compare in their impact on welfare. Some authors have equated deviations from natural behaviour with poor welfare (eg Rollin 1993), although the effect on the mental state of the animal may not always be clear. In this study, a qualitative assessment developed by Wemelsfelder *et al* (2000) was used to try to assess the affective states of tethered and free-range horses. As tethering was found to be a significant factor in explaining the lower mood scores ascribed to tethered compared to free-range horses, it seems that tethered horses at least appear to observers to have a poorer mental state than free-range horses, although observer bias cannot be ruled out. In other studies, increased vocalisations of horses during transport and handling have been associated with other measures of poor welfare and are likely to indicate social or other forms of stress (Sondergaard & Halekoh 2003; Kay & Hall 2009). The higher level of vocalisations during observations of tethered horses when compared to free-ranging horses were due to tethering and this adds weight to the argument that tethering itself has a negative effect on horse welfare. Despite this, observations of positive social interactions, such as mutual grooming, between tethered and free-ranging horses in the area suggest there may be a social benefit to both horses through being able to access a compatible companion.

The infrequent observations of severe physical welfare problems in both tethered and free-range horses indicates that notwithstanding a number of individual animals, such as those showing signs of limb pain, the general physical welfare of the horses was good. The indicator with the most frequent occurrence during observations was mane or tail tangles, which probably has little or no impact on horse welfare but is known to be a cause of concern to members of the public reporting poor welfare to the local authority (L Bishop, personal communication 2010). Ocular discharge was a relatively prevalent finding (35.4 and 28.6% of observations of tethered and free-ranging horses, respectively) where tethering was a factor explaining the more frequent occurrences found in this group and of which during approximately a quarter to a third of observations mucopurulent discharge was visible. The cause of this is not clear but if strong winds are a predisposing factor to ocular irritation the lower levels of shelter from wind for tethered horses may help explain this difference between the two groups of horses.

The habituation to people by tethered horses was evident in the more positive reaction they displayed to the observer during the approach test compared to the free-range horses. The closer interaction between humans and tethered horses compared to free-ranging horses could serve to prevent welfare problems developing or progressing, providing owners are able to do something about them. In the case of the observations of hoof cracks, tethering was a significant factor associated with high levels of cracks. It may be that the reduced mobility of tethered horses does not allow appropriate wear on the hooves and therefore predisposes to cracks (Ovnicek *et al* 2003). Although a panel of equine experts recommended that "any vertical cracks within the normal parameters of the foot (where the foot is a normal length and not too long) warrant attention", small hoof cracks in themselves are likely to constitute a welfare risk rather than a welfare problem as they were not associated with lameness or signs of limb pain in this study. Despite close contact between owners and tethered horses, in only one out of 12 observations of lesions that were associated with the headcollar or neckstrap, was there any obvious attempt to alleviate the lesion, for example by padding or alternative positioning. An example where it is likely that the care provided to tethered horses by owners improved their welfare is the higher level of supplementary feeding of tethered horses which, in turn, was probably the reason they maintained their body condition better than their free-range counterparts.

During almost all observations of free-range horses they had access to water, however the access to water for tethered horses was poor. The high proportion of horses which drank water when offered by the observer (73%) indicates either that the horses were thirsty or that they were conditioned to drink when water was offered to them. Thirst is considered an important indicator of poor welfare (Blokhuis *et al* 2003) and Pritchard *et al* (2008) showed that the response to being offered water is currently the most reliable indicator for assessing dehydration in working horses. One study of stabled horses suggested that there were no adverse welfare effects observed in horses that were offered water for 5 min three times a day compared with those that had continuous access to water (McDonnell *et al* 1999). As there was no increase in the observations of tethered horses with water at times when water might be expected to be more necessary, such as when the grass was short, the sun was shining or when temperatures were high, this suggests that either owners are not reacting to these conditions when making decisions about water provision or else additional water may have been provided outside the observation times.

The provision of shelter from wind, rain or sun was only provided to tethered horses during less than 17% of observations. This may not impact on the welfare of horses when the weather is benign but will increase the risk of poor welfare during inclement weather conditions. The evidence that horses were more likely to be observed tethered in sites with shelter from wind or sun when it is needed shows that owners are making appropriate choices for their horses, within a generally limited landscape.

Elements associated with the observations were shown to affect a number of measures across both tethered and free-range horses. For example, the closer the observer was able

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to get to the horse the more likely they were to record physical welfare problems, such as eye abnormalities and body lesions. In addition, many physical and behavioural assessments were affected by climatic conditions. For example, eye abnormalities were recorded less frequently in the rain, perhaps because watery discharge cannot be seen against a wet coat. Horses were also observed to be more alert when it was windy, and to graze less when it was sunny. Some measures showed other observer effects. For example, with increasing number of observations of a horse came a reduction in recorded lying behaviour and an increase in recorded eye and body lesions. In these cases, the time since the first observation was not a significant factor indicating that familiarity of the observer by the horse, or *vice versa*, rather than season, or increasing age, was the cause. The differences in many of the statistical models that were derived from part of the 10-min behavioural data indicate that a 5-min behavioural observation is insufficient to detect some of the less-frequent behaviours. However, it is not known if a greater length of behavioural observation is required for improved assessment.

The Code of Practice for the Welfare of Equines (Welsh Assembly Government 2008) makes several recommendations related to tethering. The results of this study and others could be used to inform changes to the guidance to provide the recommendations with a scientific evidence base where possible. Specifically, in contrast to the recommendations: there was no evidence in this study that the length of the tether or the presence of swivels affected the likelihood of entanglement in the tether; the type of material the headcollar or neckstrap was made from had no influence on whether lesions were likely to result; positive interactions were observed between free-ranging and tethered horses indicating that the presence of compatible companions could be beneficial to welfare. There were difficulties in assessing compliance with some aspects of the Code of Practice (Welsh Assembly Government 2008), for example, those aspects relating to infrequent, rather than continuous requirements, such as frequency of inspection and exercise off the tether, and therefore their effect on welfare. Whatever the wording of the Code of Practice it needs to be communicated to, and understood by, the owners of tethered horses who are ultimately expected to act in accordance with it.

Animal welfare implications and conclusion

Tethered horses had similar behavioural repertoires to free-range horses but the differences related to tethering, such as fewer observations of walking, trotting and cantering, increased vocalisations and poorer mood scores indicate that the behavioural restrictions of tethering are likely to adversely affect welfare. There were few observations of severe physical welfare problems in either tethered or free-range horses, however tethered horses were observed to have more hoof cracks, lameness, signs of limb pain and eye abnormalities but to have fewer mane and tail tangles and be less thin or dirty than their free-range counterparts. Shelter from wind, rain or sun was available to almost all free-range horses but was only observed during a minority of observations of tethered horses giving them a greater risk of poor welfare during inclement weather. Similarly, unlike for free-range horses, the limited number of observations of tethered horses having access to clean water, and their willingness to drink when offered water, suggests the provision of water is inadequate and horses may be thirsty. Sometimes owners made sensible choices to protect the welfare of their horses, such as by tethering horses in shelter during poor weather and providing supplementary feeding when needed but this did not always occur. There were significant confounding effects of the observer or climatic factors for some behavioural and physical measures that should be considered when conducting future studies. Some evidence-based changes to the Code of Practice for the Welfare of Equines (Welsh Assembly Government 2008) may be derived from this study.

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