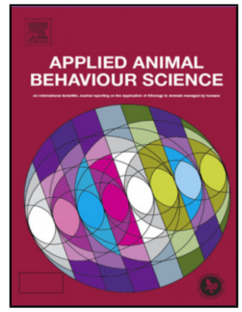

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PII: S0168-1591(17)30315-5
DOI: https://doi.org/10.1016/j.applanim.2017.11.001
Reference: APPLAN 4545

To appear in: *APPLAN*

Received date: 16-2-2017
Revised date: 8-9-2017
Accepted date: 6-11-2017

Behavioural assessment of the habituation of feral rangeland goats to an intensive farming system

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Highlights

- Habituation methodologies needed for captured feral goats transitioning to intensive rearing.
- Simple technique of increased human-animal interaction was tested.
- The human-animal interaction resulted in production performance and behavioural benefits.

Abstract

There is increasing interest in methods for the habituation of feral rangeland goats to intensive farming conditions. We tested whether there were production performance and behavioural differences between groups of rangeland goats in an intensive farming system that were either exposed to a high degree of human interaction (HI, n = 60) or low degree of human interaction (LI, n = 60) over 3 weeks. In the HI group, a stockperson entered the pens twice daily and calmly walked amongst the goats for 20 mins. In the LI group, a stockperson only briefly entered the pens to check water/feed (daily/weekly). At the end of each week the goats were weighed and drafted into 12 subgroups of 10 animals (i.e. 6 sub-groups per treatment). Each sub-group was then tested for agonistic behaviour, avoidance of humans, and flight response. During the flight response test video footage was collected and later used for analysis using Qualitative Behavioural Assessment (QBA). For QBA analysis, the videos of each group, taken each week, were shown in random order to 16 observers who used their own descriptive terms to score the groups' behavioural expression. There was a significant interaction between treatment and time on body mass ($F_{3,174} = 5.0$; $P < 0.01$), agonistic behaviour ($F_{3,12} = 4.3$; $P < 0.05$) and flight speed ($F_{3,12} = 3.9$; $P < 0.05$), with the HI group having significantly higher average body mass ($P < 0.05$), fewer agonistic events ($P < 0.05$), and a slower flight speed ($P < 0.05$) than the LI group after the three weeks. Two main QBA dimensions of behavioural expression were identified by Generalised Procrustes Analysis. QBA dimension 1 scores differed between treatments ($P < 0.05$); HI goats scored higher on QBA dimension 1 (more 'calm/content') compared to LI goats (more 'agitated/scared'). QBA dimension 1 scores were significantly negatively correlated with the number of agonistic contacts ($R_s = -0.62$, $P < 0.01$), and flight speed ($R_s = -0.79$, $P < 0.001$), and significantly positively correlated with body mass ($R_s = 0.68$, $P < 0.001$) of the goats over the 3 weeks of the experiment. QBA dimension 2 scores were not significantly different between treatments or over time. Findings from this study support the hypothesis that production performance and behavioural measures can distinguish behavioural changes in rangeland goats that were likely a result of habituation to human interaction in an intensive feedlot.

Keywords: Domestication; Feedlot; Qualitative Behavioural Assessment; Human-Animal Relationship.

1. Introduction

Domestic goats (*Capra aegagrus hircus*) of various breeds were first introduced to Australia in 1788 from England with British colonisation (Rolls, 1969). Many descendants of these goats now roam freely over rangeland (arid and semi-arid) regions of Australia (Parkes *et al*., 1996), and have effectively adjusted to the environment to the extent that they no longer bear any strong resemblance to the original breeds. These feral animals can pose a significant environmental problem if not managed appropriately, but also represent a valuable livestock resource, accounting for approximately 90% of total goat meat production in Australia (GICA, 2016). The rangeland goat industry in Australia is starting to capture and rear these animals under semi-intensive or intensive conditions to allow more efficient production and predictable supply. Consequently, best practice management and welfare assessment protocols for the transition from rangeland to intensive conditions are needed.

As part of the transition from rangeland to intensive rearing conditions, goats will experience changes in the availability or accessibility of food, water, shelter, space, and social grouping (Price 1999). Agonistic behaviour and stress-related production losses associated with confinement and mixing are significant challenges to intensive rearing of rangeland goats (Addison and Baker, 1982; Cowley and Grace, 1988; MLA, 2015). In general, goats are more reactive than sheep to a threat or perceived challenge, and they exhibit more exploratory behaviours (Kilgour and Dalton, 1984).

Behaviour is one of the most important early indicators of the welfare of an individual and its adaptation to its environment and reflects the immediate response to the interaction between the animal and its environment (Metz and Wierenga, 1997). Strategies for improving livestock animal welfare require objective measures of behaviour that will enable comparison and contrast of welfare implications. Such measures need to be versatile, relevant, reliable, relatively economic to apply, and they need to have broad acceptance and understanding by all stakeholders (Fleming *et al*., 2016). Qualitative Behavioural Assessment (QBA) is a methodological approach for capturing the body language of animals in numbers that can then be analysed statistically. An animal's body language can reveal important aspects of its physical and mental health, and therefore welfare. Boissy *et al*. (2007) suggested that Qualitative Behavioural Assessment represented one of the most immediately applicable methodologies for assessing behaviour related to welfare, both positive and negative, in animals. Previous QBA studies have shown that observers can quickly, reliably and repeatedly assess the behavioural expression of sheep (Wickham *et al*., 2012, 2015; Stockman *et al*., 2014), pigs (Wemelsfelder *et al*., 2000; Morgan *et al*., 2014; Clarke *et al*., 2016), cattle (Rousing and Wemelsfelder, 2006; Stockman *et al*., 2011, 2012), horses (Napolitano *et al*., 2008; Minero *et al*., 2009; Fleming *et al*., 2013), and dairy goats (Muri *et al*., 2013; Grosso *et al*., 2016). To date there have been no QBA studies conducted on feral goats.

One of the greatest challenges for livestock under domestication conditions is how they cope with the presence of people (Tennessen, 1989). This issue is particularly important when wild animals are held under confined conditions. Research on cattle, lambs, pigs, and dairy goats suggests that when animals have more interactions with a stockperson, they become less fearful and stressed, more productive, and healthier overall (Le Neindre *et al*., 1996; Jago *et al*., 1999; Hemsworth *et al*., 2000). In the present study we tested whether habituation to human interaction in an intensive farming system (feedlot) would improve the welfare of rangeland goats using production performance and behavioural measures, including QBA. We compared the production and behavioural responses of confined rangeland goats that were exposed to either a high degree of human interaction (a stockperson entered their pens twice daily and calmly walked amongst the goats for 20 mins) or a low degree of human interaction (the stockperson only briefly entered the pens daily/weekly to check water/feed). We further predicted that when challenged by the presence of a different person, goats in the high interaction group would show calmer behaviour that was more fitting with the domestication environment.

2. Materials and methods

These experiments were approved by the Animal Ethics Committees at Murdoch University (R2411/11; R2541/12; R2617/13) to ensure compliance with the guidelines of the Australian Code of Practice for the Care and Use of Animals for Scientific Purposes. All experiments were conducted at a private rangeland goat feedlot, Chapman Valley, WA, Australia (latitude: 28.4º S; longitude: 114.9 º E). The feedlot comprised six individual pens on either side of a central laneway that was 3 m wide.

The pens were approximately 10 x 15 m in area, providing 7.5 m^2 per animal for the 20 goats housed in each. There was one feed trough and one water trough, both of 4 m length, providing 0.2 m of trough space per animal. In the laneway that ran between the pens, a small test pen (3 x 3 m; approximately 0.9 m^2 per goat) was created at the end to hold animals during the behavioural tests. The sides of the laneway and test pen were covered with shade cloth so that the animals could not see out, and distance markers were painted on the ground. Two video cameras (GoPro Hero 3; GoPro Inc., Woodman Labs, San Mateo, CA, USA) were placed to capture continuous video footage of the goats in the holding pen and in the laneway during behavioural tests. The video footage was later analysed for each of the behavioural measures.

2.1 Animals

In late February (late summer), 120 Australian rangeland goats (*Capra hircus*), weighing 33 ± 5.9 kg (± SD, range: 22.5 – 49.5 kg), were selected from about 400 goats trapped at a water source over a period of 2 d, using a swinging one-way gate trap, on a sheep and cattle extensive rangeland grazing property, North Wooramel station, located 78 km east of Denham and 113 km south east of Carnarvon in the Gascoyne region of Western Australia (latitude: 25.6º S; longitude: 114.5 º E). The estimated age of the goats, based on dentition, was between 9 – 15 months. The goats were then immediately transported to an intensive goat feedlot in Chapman Valley situated 20 km east of Geraldton, Western Australia, an 8 h journey.

On arrival at the feedlot, goats were given three days to recover from travel and acclimatise to new conditions, with gates open between the six pens to allow freedom of movement between pens prior to treatment allocation. They were fed good quality roughage in the form of hay and *ad libitum* feed pellets, with free access to *ad libitum* water. The pellets contained 92.3% dry matter, 11.9% crude protein and 10 MJ/kg DM of metabolisable energy. The roughage was provided in the form of a round bale (approximately 400 kg) of oaten hay in each pen at the start of the experiment to provide roughage and allow acclimatisation to the pelleted feed. The hay contained 90.1% dry matter, 6.4% crude protein, 8.6 MJ/kg DM of metabolisable energy, 33.6% acid detergent fibre and 63.0% neutral detergent fibre. After acclimatisation they were given individual identification ear tags and received a 1 ml Glanvac 3 in 1 vaccine (Zoetis Australia, Rhodes, NSW, Australia) subcutaneously providing protection against *Clostridium tetani*, *Clostridium perfringens* type D and *Corynebacterium pseudotuberculosis*, a 15 ml Baycox® (Toltrazuril; Bayer AG, Leverkusen, Germany) drench for coccidia, administered orally, a 16 ml Cydectin® (Moxidectin; Virbac, Milperra, NSW, Australia) for internal parasites, administered orally, and a Clout S® (Deltamethrin; Coopers, Sydney, NSW, Australia) backline for lice.

2.2 Housing and human interaction treatments

The 120 individuals were allocated to two experimental treatment groups, split equally amongst 6 pens. The 20 goats within each pen were further subdivided into two sub-groups each of 10 goats (with two differing ear-tag colours that were individually numbered). Their allocation into the sub-groups were based on their presentation order when moved into the drafting raceway (an indication of dominance ranking; Houpt 2011), body condition score (BCS) and body mass, aiming to produce similar body mass, BCS and social structure (dominance) between sub-groups. Goats from three of the pens were assigned to the 'high' human interaction treatment (HI; 3 pens; n = 60), and the other three pens to the 'low' human interaction treatment (LI; 3 pens; n = 60). In the HI group, a stockperson entered the pen twice daily and calmly walked amongst the goats for 20 mins. In the LI group, a stockperson only entered the group pen to fill up feed bins (weekly) and clean water troughs (daily) without interacting with the goats, as was done for the HI group as well. The three HI pens and the three LI pens were located on opposite sides of the shadecloth-covered laneway so that the LI goats could not see the stockperson interacting with the goats in the HI pens.

2.3 Production measurements: body mass and body condition score (BCS)

Body condition score (BCS) and body mass were measured weekly, beginning at the start of the experiment. BCS was measured by spinal palpation of the lumbar and sternum region using the 1 - 5 scale (1 being 'emaciated' and 5 being 'fat') of Villaquiran *et al.* (2005). To maintain consistency, measurements were always performed by the same assessor. Body mass was recorded using battery-operated weigh scales, and was undertaken in the morning, following an overnight fast (accomplished by blocking access to the feed in the feed bins).

2.4 Behavioural measurements

Assessments were made on each treatment group weekly, on the same day, over the 3 weeks of the study, beginning at the end of the first week. All the goats from an individual pen were initially drafted into the 2 sub-groups of 10 animals, based on ear-tag colour, as the goats were weighed and condition scored. Each sub-group was then moved into a small test pen at the end of the 3 m wide laneway for the behavioural tests. After the behaviour tests were completed for the first sub-group, these goats were returned to their home pen, and the next sub-group was calmly herded into the test pen. This procedure was repeated for each pen, with the whole process taking about 3 h.

2.4.1 Agonistic contact test

The number of agonistic behaviours displayed in the first 2 mins of being held in the test pen was analysed from the recording from the video camera. A modified ethogram (Shank, 1972; Andersen and Bøe, 2007) was used to denote agonistic behaviours, as for previous goat studies:

- Butting (one goat makes contact with another goats body with the head using force)
- Rearing front clash (one or both individuals rear up on their hind legs and clash facing forward into the head or shoulders)
- Front clash (no rearing displayed but two individuals clash heads or shoulders with force)
- Side head butt (two goats stand parallel close together and jerk heads sideways toward each other. The horns make contact with each other or with the shoulder regions)

2.4.2 Approach to feed

A container with young mulga (*Acacia aneura*) branches and leaves, a particularly favourite native feed for goats (Harrington, 1986), was placed in the laneway 10 m in front of the gate to the test pen. A person (not the usual stockperson, but the same person for each behaviour test replicate, and wearing the same clothing; i.e. a white lab coat), stood motionless 5 m on the far side of the food container from the goats. The test pen was then opened remotely (using a rope pulled by another person hiding 20 m away). Behaviour of the goats was recorded by a video camera attached to the laneway fence. From the video camera footage, we recorded

- approach distance to the food (average distance between the test pen gate and the closest approach to the food container made by each goat in a 2 min period); and
- the number of individuals that fed in a 2 min period.

2.4.3 Flight response test

The flight zone is the area surrounding an animal that if encroached upon by a potential threat, including a human, will cause escape behaviour. Observations on sheep and cattle have shown that the size of the flight zone of an individual animal will vary depending on how 'tame' the animal is, and the size of the flight zone has been used as a measure to discriminate between feedlot and rangeland cattle (Grandin, 1978). To record flight zone responses, the goats were gently herded back into the test pen and left to settle for 5 mins. The food container was removed from the laneway and the pen was then opened remotely into the laneway where a person was standing motionless 20 m away (not the usual stockperson, but the same person for each behaviour test replicate, and wearing the same clothing). After 1 min, the person slowly approached the goats at a slow walking speed (1.5 m/s). When the flight response was induced, the person stopped still after all the goats had run past (NB: there was never more than 1 stride-length (~0.5 m) between when the first and the last goat passed the person). Using footage collected by the video camera in the laneway, we recorded

- the distance that the person had approached towards the goat group at the time that all the goats ran past; and
- the average speed at which the goats ran past and away from the person (measured over a distance of 25 m).

2.5 Qualitative behavioural assessment (QBA)

Video footage recorded for the flight response test was used for QBA. Footage from the video camera was edited into clips (approximately 75 s -duration) commencing immediately after the test pen was opened, with the footage edited at the end so that observers of the footage did not see the human enter the field of view. Sixteen observers of the QBA video footage were mainly recruited from the Murdoch University School of Veterinary and Life Sciences staff and students, including some (n = 5) from rural (farming) backgrounds. Observers were given detailed instructions on completing the QBA scoring sessions but were not given any details on the goats themselves or the experimental treatments. The sessions are detailed below.

2.5.1 Term generation (session 1)

Observers were shown 10 video clips of groups of goats during the flight response test. These clips were selected from footage using other similar goats on the property (n = 7) or from unidentifiable footage that was also shown in session 2 (n = 3). Clips were chosen that demonstrated a wide range of behaviour to allow observers to describe as many aspects of the goats expressive repertoire as possible. After watching each clip, observers were given 1 min to write down any words that they thought described that animal's behavioural expression. There was no limit imposed to the number of descriptive terms an observer could generate, but terms needed to describe not *what* the animal was doing (i.e. physical descriptions of the animal such as vocalising, chewing, tail flicking), but the perceived emotional state of the animal (e.g. nervous, relaxed). Subsequent editing of the descriptive terms was carried out to remove terms that described actions, and terms that were in the negative form were transformed to the positive for ease of scoring (e.g. *unhappy* became *happy*). Each descriptive term was attached to a 100 mm visual analogue scale (minimum = 0 to maximum = 100). The list of terms was randomly arranged, although terms with a similar meaning were not listed together.

2.5.2 Quantification (sessions 2)

Observers viewed and scored video clips of groups of goats using their own unique list of descriptive terms. In session 2, observers viewed 36 clips of the different treatment groups of goats during the flight response test. Before session commencement, observers were given detailed instructions on how to score each animal's expression using the visual analogue scale: they were told to think of the distance between the zero-point and their mark on the scale as reflecting the intensity of the animal's expression. The observers were not told that they had been recently brought to the feedlot from the rangelands or that the goats were exposed to different levels of interaction with people.

2.6 Statistical analyses

For QBA analysis, the distance from the start of the visual analogue scale to where the observer had made a mark was measured in millimeters and these measurements were entered into individual observer Excel files (Microsoft Excel 2003, North Ryde, NSW, Australia). These data were submitted to statistical analysis with Generalised Procrustes Analysis (GPA) as part of a specialised software package written for Françoise Wemelsfelder (Genstat 2008, VSN International, Hemel Hempstead, Hertfordshire, UK; Wemelsfelder *et al.*, 2000). For a detailed description of GPA procedures, see Wemelsfelder *et al*. (2000). Briefly summarised, GPA calculates a consensus or 'best fit' profile between observer assessments through complex pattern matching. GPA provides a statistic (the Procrustes Statistic) which indicates the level of consensus (i.e. the percentage of variation explained between observers) that was achieved. Whether this consensus is a significant feature of the data set, or, alternatively, an artefact of the Procrustes Statistic, is determined through a randomisation test (Dijksterhuis and Heiser, 1995). This procedure rearranges, at random, each observer's scores and produces new permutated data matrices. By applying GPA to these permutated matrices, a 'randomised' profile is calculated. This procedure is repeated 100 times, providing a distribution of the Procrustes Statistic indicating how likely it is to find an observer consensus based on chance alone. Subsequently a one-way *t*-test is used to determine whether the actual observer consensus profile falls significantly outside the distribution of randomised profiles.

Through Principle Components Analysis, the number of dimensions of the consensus profile is then reduced to several main dimensions (usually 2 or 3) explaining the variation between groups. Each goat group viewed by the observers receives a quantitative score on each of these dimensions, so that the group's position in the consensus profile can be graphically represented in two- or three-dimensional plots. Each plot represents the results from each QBA session, where the position of the goat group indicates its scores on each GPA axis.

GPA dimensions are interpreted by correlating the animals' scores to the observers' individual scoring patterns, producing individual observer word charts that describe the consensus dimensions through their association with each individual observer's terms. These word charts can then be compared for linguistic consistency. From these word charts, a list of terms describing the consensus dimensions was produced, by selecting terms for each observer that correlated strongly with those dimensions.

For the production traits, body mass and body condition score, analyses were conducted using repeated measures analysis of variance (RM-ANOVA: Genstat 2008, VSN International, UK) on individual animal data followed by Tukey's Honest Significant Difference ('Tukey') test. Human interaction treatment and time served as the independent variables. For the quantitative behavioural traits, agonistic contacts, approach to feed and flight response, analyses were conducted by RM-ANOVA on sub-group data followed by the Tukey test. For the qualitative behavioural assessment, GPA scores for dimensions 1 and 2, analyses were conducted by RM-ANOVA on sub-group data followed by the Tukey test. The association between the quantitative behavioural results and GPA dimension scores for the video clips were analysed by Spearman Rank Order correlation (Rs; Genstat 2008, VSN International, UK). All data were tested for normality (Shapiro-Wilk test: Genstat 2008, VSN International, UK).

3. Results

3.1 Body mass and body condition score (BCS)

RM-ANOVA indicated that there was no effect of the human interaction treatments, but a significant effect of time ($F_{3,174} = 6.3$; $P < 0.001$) and the interaction between treatment and time ($F_{3,174} = 5.0$; $P < 0.01$) on body mass (Fig. 1). HI group had a 30% increase in body mass over the entire experimental period ($F_{3,174} = 6.8$; $P < 0.001$), and the LI group had a 20% increase in body mass over the same period ($F_{3,174} = 5.6$; $P < 0.001$). Post hoc comparisons indicated that the body mass for the HI group significantly increased (Tukey, $P < 0.05$) every week of the experiment (Week 0 mean = 32.6 ± 0.8 kg SEM versus Week 1 mean = 38.4 ± 0.8 kg versus Week 2 mean = 40.7 ± 0.7 kg versus Week 3 mean = 42.2 ± 0.8 kg). The body mass increased (Tukey, $P < 0.05$) for the LI group after the first week of the experiment (Week 0 mean = 34.2 ± 0.8 kg versus Week 1 mean = 41.5 ± 0.8 kg), but their body mass gain stopped thereafter. At the end of the three weeks the average body mass of the HI group was significantly higher (Tukey, $P < 0.05$) than the average body mass of the LI group (HI mean = 42.2 ± 0.8 kg versus LI mean = 39.6 ± 0.6 kg). Body condition score (BCS) of the goats did not vary significantly over the duration of the experiment in either group (Week 0: HI mean = 1.75 ± 0.04 BCS units versus LI mean = 1.80 ± 0.04 BCS units; Week 3: HI mean = 1.77 ± 0.04 BCS units versus LI mean = 1.83 ± 0.05 BCS units).

3.2 Behaviours

3.2.1 Agonistic behaviour

RM-ANOVA indicated that the number of agonistic contacts when goats were confined in the test pen for 2 min showed an effect of human interaction treatment ($F_{1,4} = 8.1$; $P < 0.05$), time ($F_{3,12} = 3.8$; $P < 0.05$) and the interaction between treatment and time ($F_{3,12} = 4.3$; $P < 0.05$). The number of agonistic contacts between the treatment groups was similar in Week 1, but significantly different (Tukey, $P < 0.05$) between the treatment groups in Weeks 2 and 3 (Fig. 2). The HI sub-groups had 55% and 60% fewer agonistic contacts in weeks 2 and 3 compared to the LI group, respectively. The number of agonistic contacts increased by about 30% in Week 2 for the LI sub-groups compared to Weeks 1 and 3 (Tukey, $P < 0.05$), while the number of aggressive contacts in the HI sub-groups significantly decreased over time, with the number of agonistic contacts decreasing by 53% between Weeks 1 and 3 (Tukey, $P < 0.05$).

3.2.2 Approach to feed

The average distance of approach to the food showed no effect of human interaction treatment, time, or the interaction between treatment and time (Fig. 3a). The increase in the average distance of approach of the HI sub-groups over the three weeks approached significance (Tukey, P = 0.06), but at no weekly time-point was the average distance of approach of the HI sub-groups significantly different to the LI sub-groups. There was no human interaction treatment difference in terms of the number of goats within a group that made it to the feed container (Fig. 3b). The increase in the average number of goats that fed in the HI sub-groups over the three weeks approached significance (Tukey, P = 0.09), but at no weekly time-point was the average number of goats that fed in the HI sub-groups significantly different to the LI sub-groups.

3.2.3 Flight response

The distance of approach by the person towards the goat group before they ran past showed no effect of human interaction treatment, time or the interaction between treatment and time (Fig. 4a). There was a significant difference between the HI and LI sub-groups (Tukey, $P < 0.05$), but only in Week 3. In week 3, the HI sub-groups ran past as the person approached by a distance of 4.3 ± 0.8 m, while the LI sub-groups ran past as the person approached by a distance of 2.6 ± 0.1 m. However, there was no difference over time in the HI sub-groups, the difference arose because the approach distance by the person in the LI sub-groups was significantly lower before eliciting the flight response in Week 3 compared to both Weeks 1 and 2 (Tukey, $P < 0.05$).

RM-ANOVA indicated that the speed at which the goats ran past the approaching person showed an effect of human interaction treatment ($F_{1,4} = 9.6$; $P < 0.05$), time ($F_{3,12} = 4.1$; $P < 0.05$) and the interaction between treatment and time ($F_{3,12} = 3.9$; $P < 0.05$). In both treatment groups, flight speed decreased over the 3-week experimental period ($F_{3,12} = 3.8$; $P < 0.05$), but decreased faster in the HI sub-groups (Fig. 4b). The speed of the HI sub-groups decreased by 45% from Week 1 to Week 3 (Tukey, $P < 0.01$), while the speed of for the LI sub-groups decreased by 17% from Week 1 to Week 3 (Tukey, $P < 0.05$).

3.3 Qualitative behavioural assessment (QBA)

The 16 observers participating in this study generated a total of 87 unique terms to describe the goat groups they were shown, with an average of 13 ± 6 (min: 6, max: 25) terms per observer. The Procrustes Statistic generated from the GPA analysis of the video footage was 42.2% and this differed significantly ($P < 0.001$) from the mean randomised profile, indicating significant consensus between observers in their use of descriptive terms to quantify the behavioural expression of the groups of goats.

Figure 5 represents an example of one observer's terms graphed against GPA dimensions 1 and 2. Two main QBA dimensions were identified, explaining a total of 70.1% of the variation between animals. For QBA dimension 1, explaining 57.0% of the variation between animals, low values were associated with terms such as *agitated* and *scared* and high values with terms such as *calm* and *content*, grouped together to generally describe the valence state of the animals. For QBA dimension 2, explaining 13.1% of the variation between animals, low values were associated with terms such as *confused* and *nervous* and high values with terms such as *confident* and *dominant*, grouped together to generally describe the arousal state of the animals. The most frequently used terms, described above, were selected for the purpose of labelling the QBA dimensions in relation to treatment (HI *vs.* LI human interaction) (Fig. 6 & 7).

RM-ANOVA indicated that goats in the HI treatment group scored significantly higher ($F_{1,4} = 8.4$; $P < 0.05$) on QBA dimension 1 (i.e. goats were scored as more 'calm/content'; Fig. 6) compared to goats in the LI treatment group (which were more 'agitated/scared'). There was a significant effect of time on QBA dimension 1 ($F_{3,12} = 11.1$; $P < 0.001$), but not for the interaction between treatment and time (Fig. 7). GPA dimension 1 scores for the HI group increased from week 1 to 2 (Tukey, $P<0.001$) and from week 1 to 3 (Tukey, $P < 0.001$). The GPA scores in QBA dimension 1 for the LI group increased from week 1 to 2 (Tukey, $P < 0.001$) but decreased from week 2 to 3 (Tukey, $P < 0.05$), so at week 3 the GPA score for the HI group was higher (Tukey, $P<0.001$) than the LI group (Fig. 7). QBA dimension 1 scores were positively correlated with body mass ($R_s = 0.68$; $P < 0.001$), and negatively correlated with agonistic contacts ($R_s = -0.62$; $P < 0.01$) and flight speed ($R_s = -0.79$; $P < 0.001$) (Table 1). Therefore, goats that were described as more 'calm/content' gained weight, showed less aggression, and had a slower flight speed.

There were no treatment effects on QBA dimension 2 and no effect of time or the interaction between treatment and time on QBA dimension 2. QBA dimension 2 scores (*confident/dominant vs. confused/nervous*) were not correlated with any of the quantitative behavioural or production performance measures.

4. Discussion

Using behavioural and production performance measures, feral rangeland goats that were exposed to a higher degree of human interaction were described as more 'calm/content' by QBA analysis, showed less aggression, had a reduced flight response, and gained more weight by the end of the experiment. These findings support the hypothesis that production performance and behavioural measures can distinguish changes in rangeland goats that were likely a result of the habituation of the rangeland goats to human interaction in an intensive feedlot. The findings also indicate that the simple habituation technique of a stockperson calmly walking through the pens of rangeland goats has behavioural and production performance benefits. Although there have been no previous behavioural studies on the effects of intensive farming (feedlotting) of feral goats, sheep studies have found negative effects of feedlotting (Rice *et al.*, 2016a, b). Therefore, studies into best practice management and welfare assessment protocols for the transition of rangeland goats from rangeland to intensive conditions are required. The overall findings from the present study agree with a review by Grandin (1984) that methods of reducing handling stress of animals, including habituation to human presence techniques such as the one in the present study, will improve the animals' performance and welfare.

After three weeks of a higher degree of human interaction, the goats showed less aggression and had a reduced flight speed. These findings agree with previous research on cattle, sheep, pigs and dairy goats that indicate that animals become less fearful and stressed if they have had more interactions with a stockperson (Le Neindre *et al*., 1996; Jago *et al*., 1999; Hemsworth *et al*., 2000). In a previous study using rangeland goats, with a similar agonistic-behaviour test protocol, we found a gradual decrease in the number of agonistic contacts over time in the control group that received similar levels of human interaction as the low interaction group in the present study, but the decrease wasn't significant until 8 weeks after the start (Bishop *et al*., 2015). It appears that there may be a gradual acclimatisation by the rangeland goats to the intensive feedlot system, maybe involving establishment of a social hierarchy and acclimatisation to the new environment, that results in reduced agonistic behaviour over time. But it also appears that this habituation process is hastened with a higher degree of interaction with a stockperson. The amount of fighting between animals is correlated with various physiological changes, including increases in plasma concentrations of adrenaline, noradrenaline, cortisol, testosterone, and central neurotransmitters like dopamine and serotonin (Scott, 1966; Seo *et al*., 2008; Bishop *et al*., 2015). These changes are undoubtedly related to various stressors, but the exact physiological mechanism whereby a higher degree of human interaction reduces fighting over time is not known. In terms of the reduced flight speed in the rangeland goats that had a higher degree of human interaction, the findings partially agree (i.e. flight speed but not the flight zone) with a study by Grandin (1978) that showed that the flight response can be used as a measure to discriminate between feedlot and rangeland cattle, likely reflecting habituation to the higher level of human interaction for feedlot cattle.

The lack of overall effect of the human interaction treatments on the distance of approach before flight, although it was significant at week 3, indicates that this test may not be an appropriate quantitative measure of habituation in this context. Hutson (1982) found in sheep, using a similar test design, that there was no effect of approach speed by the stockperson, indicating that this test is perhaps unable to differentiate an increased 'potential threat'. Similarly, the quantitative test of 'approach-to-feed-with-a-human-present' also was unable to differentiate between the human interaction treatments, or the overall effect of time, in the present study. Waiblinger *et al*. (2006), in a review of the human-animal relationship in farmed species, stated that tests designed to measure the animal's reactions to human beings have many confounding factors, such as the characteristics of the human, the animal's pre-test conditions, and the environment where the test is carried out. Perhaps this highlights the view by Martin and Bateson (2007) that the suitability of a particular quantitative behavioural measure needs to be carefully considered in relation to the context of the study.

The qualitative behavioural expression of the rangeland goats in the two human interaction treatment groups were significantly different, and QBA scores also showed evidence for a change in qualitative behavioural expression over time. These findings agree with a study by Minero *et al*. (2009) that found differences in qualitative behavioural expression for yearling foals assessed before and after having received a month-long human interaction treatment. The treatment and time effects were only found to be significant for QBA dimension 1 and not dimension 2 in the present study. GPA dimension 1 generally used terms semantically consistent with a valence of mood, while GPA dimension 2 had terms reflective of general energy level. Valence and arousal have similarly been reported on the first two dimensions of QBA analyses in other species (e.g., sheep, Phythian *et al*., 2013; pigs, Clarke *et al*., 2016). The association between QBA and the quantitative behavioural measures in the present study, as well as the goats' production performance, suggests that this method can identify real attributes of rangeland goat habituation to humans in an intensive farming environment, rather than being an artefact of observer interpretation. Previous studies have also validated QBA findings against quantitative behavioural, physiological and performance data in cattle, sheep, pigs, dairy goats, dogs and horses (reviewed by Fleming *et al*., 2016), but to the authors' knowledge this is the first study in feral goats.

5. Conclusion

We have shown that the simple habituation technique of a stockperson calmly walking through the pens of feral rangeland goats results in behavioural and production performance benefits, and that quantitative and qualitative measures were able distinguish the behavioural changes that were likely as a result of the habituation of the goats to humans. Many of the occasions on which animals and humans interact in current farming practices are perceived as negative, e.g., invasive veterinary or husbandry procedures, isolation and/or restraint, etc., while, other than feeding, few are positively reinforcing. Simple-to-implement animal husbandry techniques that have possible positive outcomes in terms of behaviour, welfare and production performance, such as the technique described in this study, should be encouraged in all animal industries.

Acknowledgements

Thanks to the Keynes family of Chapman Valley Capretto & Chevron for access to facilities, animals, extra labour and invaluable advice. This study was funded by Meat & Livestock Australia (project no. W.LIV.0159).

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Figure captions

Fig. 1. Average body mass (kg) over the three week experimental period for the goats in the high human interaction group (HI – solid line; n = 60) and the low human interaction group (LI – dashed line; n = 60). Values are means ± SEM. Asterisks indicates significant difference between treatment groups ($P < 0.05$).

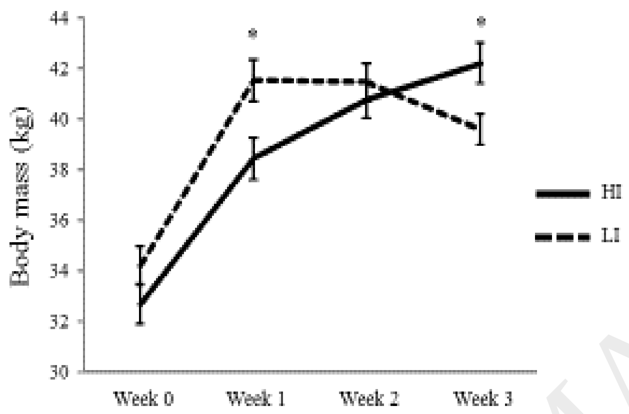

Fig. 2. Average number of agonistic contacts per sub-group (10 goats; per 2 min) over the three week experimental period for the goats in the high human interaction group (HI – black bars; n = 6) and the low human interaction group (LI – white bars; n = 6). Values are means ± SEM. Asterisks indicates significant difference between treatment groups ($P < 0.05$).

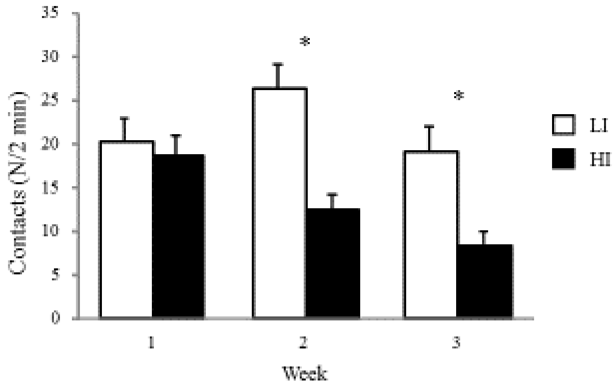

Fig. 3. (a) Average distance (m) of approach from the opening of the holding pen to a feed container with a human present; and (b) the number of individuals that fed with a human present, per sub-group (10 goats; per 2 min), over the three week experimental period for the goats in the high human interaction group (HI – black bars; n = 6) and the low human interaction group (LI – white bars; n = 6). Values are means ± SEM.

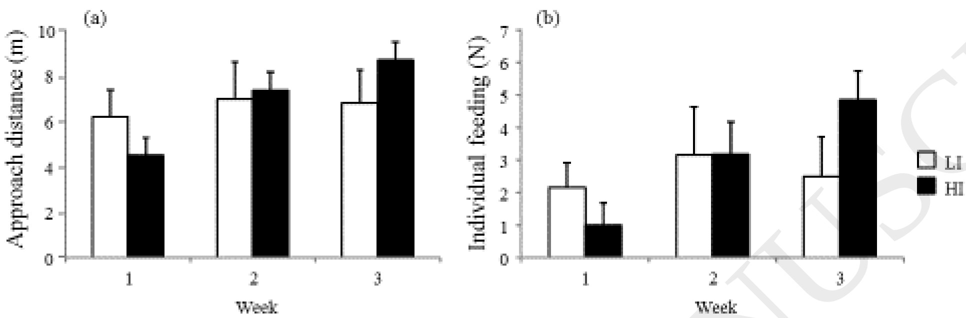

Fig. 4. (a) Average distance (m) between the approaching human and the goat group before eliciting the flight response; and (b) the average speed (m/s) that the goat group achieved (measured over 25 m), per sub-group (10 goats), over the three week experimental period for the goats in the high human interaction group (HI – black bars; n = 6) and the low human interaction group (LI – white bars; n = 6). Values are means ± SEM. Asterisks indicates significant difference between treatment groups (*P* < 0.05).

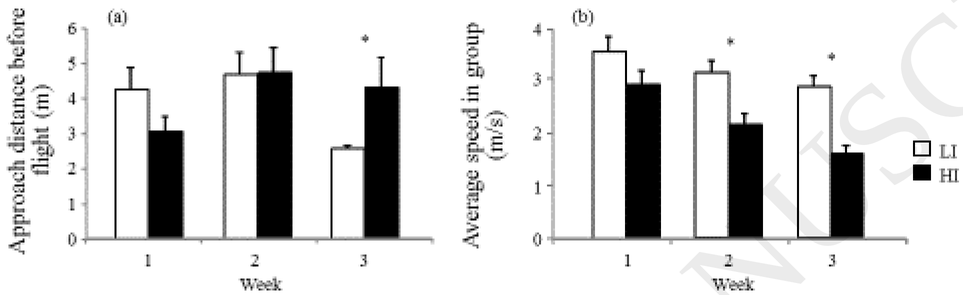

Fig. 5. Representative word map of a consensus profile for Generalised Procrustes Analysis (GPA) scores from the Qualitative Behavioural Assessment (QBA) dimensions 1 and 2 for one observer viewing the goat sub-groups from video footage taken as a human approached before eliciting the flight response.

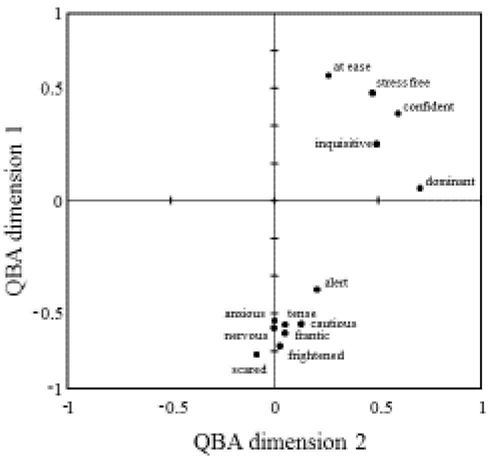

Fig. 6. Positions of the goat sub-groups are shown (represented by lower case letters to represent ear-tag colour sub-groups; p: pink, o: orange, g: green, b: blue, w: white, y: yellow) in high human interaction (H) and low human interaction (L) treatment groups, assessed in week 1 (1), week 2 (2) and week 3 (3) on Qualitative Behavioural Assessment (QBA) dimensions 1 and 2 obtained from General Procrustes Analysis (GPA) scores of observers watching video footage taken as a human approached before eliciting the flight response.

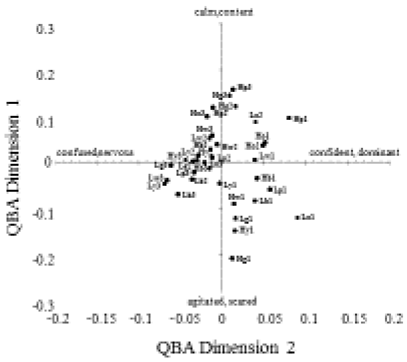

Fig. 7. Effects of high human interaction (HI - solid line; n = 6) and low human interaction treatments (LI - dashed line; n = 6) upon General Procrustes Analysis (GPA) scores in Qualitative Behavioural Assessment (QBA) dimension 1 assessed using weekly video footage (over a 3 week period) of the goat sub-groups taken as a human approached before eliciting the flight response. Values are means ± SEM. Asterisks indicate significant difference between treatment groups (*P* < 0.001).

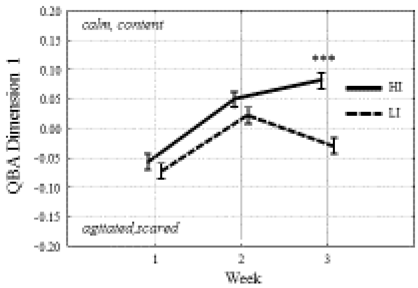

Table 1 The correlation of quantitative measures with Qualitative Behavioural Assessment (QBA) using the General Procrustes Analysis (GPA) dimension 1 scores

	QBA dimension 1 scores (Spearman correlation coefficients; R_s)
Quantitative measures	(*calm/content vs agitated/nervous*)
Body mass	0.68***
Body condition score	0.07
Number agonistic contacts	-0.62**
Approach to feed (with human present)	0.23
Number feeding (with human present)	0.34
Human approach distance for flight	0.26
Flight speed	-0.79***

Asterisks indicate statistical difference: ** = $P < 0.01$, *** = $P < 0.001$