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Animal Welfare 2013, 22: 385-400
ISSN 0962-7286
doi: 10.7120/09627286.22.3.385

Development and testing of an on-farm welfare assessment protocol for dairy goats

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Abstract

*To ensure that farm animal welfare issues are identified and addressed appropriately, there is a need for robust on-farm welfare assessment protocols. This paper describes the development of a comprehensive welfare assessment protocol for dairy goats (*Capra hircus*) and its testing on 30 commercial dairy goat farms in Norway. The protocol combines animal-based welfare indicators with measures of husbandry provisions to enable the identification of welfare problems and challenges inherent to the production system. The study also includes a first report of group level qualitative behavioural assessments (QBA) of goats. Due to reliability and validity issues related to behavioural assessments of human-animal interactions, indices of stockperson attitudes were incorporated as a complementary assessment of stockmanship. The most prevalent physical conditions observed were ocular discharge, skin lesions, udder asymmetry, calluses on knees and hocks, and overgrown claws. Moreover, fear levels appeared to be of particular concern in some herds. Significant associations were found between qualitative behavioural assessments and measures of health and stockmanship. Floor type was associated with four animal-based welfare outcomes. Reliability and validity of goat welfare indicators need to be further tested, and intervention plans and thresholds need to be determined so that advice can be tailored to the specific problems identified on each farm. We conclude that the protocol can work as a tool to identify welfare issues in dairy goat herds, and that this study may be a valuable contribution to the development of a much-needed welfare assessment protocol for dairy goats.*

Keywords: *animal welfare, behaviour, dairy goats, health, human-animal relationships, stockmanship*

Introduction

In order to identify and address welfare problems in the dairy goat industry, there is a need for robust and scientifically validated on-farm welfare assessment protocols. Resource provisions, like space allowance and air quality, can be measured objectively (Webster 2003; Whay *et al* 2003) and thus be used to ensure compliance with current legislation, which by and large sets requirements relating to resources. However, they do not provide sufficient information about the actual welfare outcome (Webster *et al* 2004). To rectify this, recent work on farm animal welfare assessment has been focused on implementing more direct animal-based welfare indicators.

Comprehensive on-farm welfare assessment protocols have been developed for several of the most commonly farmed species. Examples are the protocols developed through the Welfare Quality® project (Canali & Keeling 2009; Blokhuis *et al* 2010) and the Bristol Welfare Assurance Programme (BWAP) (Main *et al* 2004, 2007), both providing protocols for cattle, pigs and poultry. The Five Freedoms (Farm Animal Welfare Council 1993) are widely accepted as a sound framework for identifying elements that may compromise animal welfare. The Bristol Welfare Assurance Programme (BWAP) has based the welfare assessment on the logics of the Five Freedoms, while the Welfare Quality® protocols are based on 12 criteria, building on and extending the Five Freedoms (Blokhuis *et al* 2010). No formal welfare assessment protocol exists for goats (*Capra hircus*), and to our knowledge, only one paper has published empirical data from overall welfare assessment of this species (Anzuino *et al* 2010).

Qualitative behavioural assessments are summations of overall behavioural expressions that may help observers interpret the meaning of behaviours for the animal's welfare state (Wemelsfelder & Farish 2004). The method has been incorporated into the Welfare Quality® protocols, eg the protocol for dairy cattle (Knierim & Winckler 2009). A study of individual differences in goats' temperament utilised a similar approach to rate individual goats' behaviour in the milking parlour (Lyons 1989), but to our knowledge, no published work exists regarding the use of this method for goat welfare assessments at group level.

Research in other species has shown that the standard of stockmanship may have major impacts on farm animal welfare, and considerable between-farm variations have been documented in farm animals' responses to humans (de Passillé & Rushen 2005; Hemsworth *et al* 2009). It is therefore essential to include measures of stockmanship and human-animal relationships in welfare assessment protocols. Due to unresolved reliability issues with regards to behavioural tests (de Passillé & Rushen 2005), measures of stockperson characteristics, like attitudes (Hemsworth *et al* 2009), may be included in welfare assessments to provide complementary information about causes of reduced welfare.

Conditions affecting the integumentary system, injuries, lameness and body condition score have been proposed as relevant health parameters in the assessment of goat welfare (Caroprese *et al* 2009). Although there is scientific literature addressing physical conditions that have the potential to cause pain or discomfort in goats, like mammary infections (eg Contreras *et al* 2003; Mavrogianni *et al* 2004, 2011) and lameness (Hill *et al* 1997; Christodoulopoulos 2009), empirical data addressing the welfare consequences of these conditions are virtually non-existent. Quantification of pain by means of physiological measures and behaviour has only been attempted in relation to routine management procedures (Greenwood & Shutt 1990; Alvarez *et al* 2009; Alvarez & Gutiérrez 2010) and experimentally induced pain (Houzha *et al* 2011). Mastitis is one of the most important clinical diseases in goats (Mavrogianni *et al* 2011), and different stages of acute mastitis with gangrene were among the conditions considered most painful in dairy goats by stockpeople in Norway (Muri & Valle 2012). Indicators of udder health are therefore of obvious importance in the assessment of goat welfare. In addition, known variations in national or regional prevalences of infectious diseases will determine the relevance of including different disease symptoms.

The welfare of goats in Norway is regulated through the Animal Welfare Act (Norwegian Parliament 2009) and the regulation regarding welfare for small ruminants (Norwegian Ministry of Agriculture and Food 2005). The Norwegian Food Safety Authority (NFSA) is responsible for enforcing the legislation, but does not have standardised, scientifically validated protocols for inspections. The national dairy goat population consists of approximately 35,000 animals, distributed in 364 commercial herds (Statistics Norway 2012), and the industry has previously struggled with high prevalences of caseous lymphadenitis (CLA), caprine arthritis-encephalitis (CAE) and Johne's disease (paratuberculosis) (Leine *et al* 2005). Over the past decade, the Goat Health Service in Norway has run a disease eradication programme, Healthier Goats (Leine *et al* 2005), with the aim of eradicating these diseases from Norwegian dairy goat herds. The associations between disease eradication status and welfare indicators assessed by the use of the protocol described in this paper are addressed in a follow-up to this study (Muri *et al*, submitted).

Aims

The primary aim of this study was to develop and test an on-farm welfare assessment protocol for dairy goats, based on the logics of the Five Freedoms (Farm Animal Welfare Council 1993) and existing protocols for other species, with particular emphasis on animal-based welfare indicators and stockmanship. Secondly, we wished to use the data collected from 30 commercial dairy goat farms to identify prevalent welfare issues and to explore how measures of stockmanship and resource provisions are related to welfare outcomes. By these means we wish to contribute to the development of a scientifically based, on-farm, welfare assessment protocol for dairy goats.

Materials and methods

Development of the protocol

A group consisting of animal welfare scientists and veterinary surgeons with expertise in goat health and management initially discussed potential welfare indicators for goats. A thorough review of the literature on goat health and welfare, and existing recommendations and legal requirements for dairy goat farms was conducted to identify issues and conditions that are considered relevant for goat welfare. Scientific literature on other species was consulted regarding issues inadequately described for goats, and some animal-based parameters were included based on extrapolation from other species. Different sections of the dairy cow protocols developed by BWAP (Main *et al* 2004, 2007) and the Welfare Quality® project (Welfare Quality® 2009) were used as guides to design the first drafts. During the development of the protocol, KM visited several commercial dairy goat farms to test the scoring systems and assess the feasibility and relevance of the parameters and methods in collaboration with an experienced goat practitioner. Modifications were made to the protocol based on these experiences. Later versions were tested and practiced on farms together with the two observers who took part in the final data collection. Of the three observers, two were veterinary surgeons and one was an ethologist. The behavioural expressions applied in the qualitative behavioural assessments (QBA) were initially a subset of the 20 descriptors used in the Welfare Quality® protocol for dairy cows. However, some descriptors were modified or aggregated based on the observers' consensus about their meaning and importance. The final descriptors were 'resting', 'aggressive', 'inquisitive/interested', 'fearful' and 'calm and indifferent'. Body condition scoring was practiced and calibrated with an experienced dairy goat advisor from TINE SA, the major dairy co-operative in Norway. During the final run-through of the protocol, all parameters were independently scored on the same 20 animals by the three observers. The levels of inter-rater agreement were used to modify scoring categories or their descriptions, and were discussed to clarify any ambiguity about cut-off points between scores. The final protocol included detailed guidance notes, diagrams and colour photographs to illustrate different variables and their scores. The protocol will be made available upon request.

Sampling, inclusion criteria and recruitment

Due to financial restrictions, the number of farms had to be limited to 30. The reference population was the total national population of dairy goats, in which the predominant breed is the Norwegian dairy goat. The target population was all dairy goat farms included on contact lists obtained from the Goat Health Service and the Goat Milk Recording System (GMRS), which is owned by TINE SA. GMRS enrolment was 89.4% of the herds at the time the farms were recruited (TINE Rådgivning 2011). Furthermore, the inclusion criteria for the study were as follows:

• Participation in a questionnaire-based study of human-animal relationships in the dairy goat industry (Muri & Valle 2012; Muri *et al* 2012), to enable the future assessment of relationships between welfare indicators and measures of farmers' goat-oriented attitudes and empathy;

• Enrolled in GMRS in 2009, and consented to use their data from the GMRS database (asked for in the aforementioned questionnaire);

• Geographical location in western Norway (counties of Møre og Romsdal, Sogn og Fjordane, Hordaland, Rogaland and western parts of Telemark);

• Conventional farm with a minimum of 50 dairy goats; and

• Finally, the sample was balanced on disease eradication status: 15 farms that had completed the Healthier Goats eradication programme no later than 2007, and 15 farms that had not started work related to the eradication programme at the time of data collection. This last criterion was required for the follow-up to this paper, which specifically addresses the welfare effects of disease eradication (Muri *et al*, submitted).

All farmers that fulfilled the inclusion criteria were sent written information about the project in advance, and then contacted by telephone. Of 50 farms initially contacted, 35 were positive about participation. The final selection of farms was based on geographic proximity to other farms, and the farmers' availability in the period of the farm visits.

Data collection

A total of 30 farms were visited. The three observers each collected data from ten unique farms during three weeks in November 2010. On each farm, all data were collected on the same day and by the same person, and the observations started an hour after completion of morning feeding. The observers were dressed in identical, blue disposable overalls. In addition, they wore disposable plastic covers on their boots for bio-security reasons. After entering the animal housing, an initial period of 5 min was spent slowly moving around in the building to habituate the animals to the presence of the observer. Then, the whole group of dairy goats was observed for 20 min. During this period, qualitative behavioural assessments were undertaken, and the proportions of animals expressing each of the five pre-defined behavioural expressions were registered on visual analogue scales (VAS). The number of coughs heard and any lame or obviously sick or dull animals were also registered during this observation period.

After the initial behavioural observations, the stockperson was asked to assist by marking the animals to be subjected to clinical examinations. The observer randomly selected 20 adult dairy goats in each herd, making sure to select goats from all parts of larger pens and representing all pens according to group size. The observer stood outside the pens and instructed the farmer to approach and mark each selected goat on the head with the marking crayon. As a measure of human-animal interactions, the farmers' behavioural style and the goats' behavioural responses during this procedure were observed and registered on five-point rating scales (handling test). The lowest approach score represented positive physical and verbal interactions, like petting and gentle talking, while the highest score represented negative interactions, like chasing, tugging hair and shouting. The categories for the goats' responses were corresponding, with a low score representing a positive reaction; approaching the stockperson willingly and initiating physical contact. The highest score indicated high levels of fear, with strong avoidance. To avoid biased behaviour, farmers were not informed that their behaviour was assessed. As the goats walked away from the farmer after being marked they were gait scored on a four-point lameness scale (modified from Flower & Weary 2008). The selected goats were subsequently restrained for the ease of performing the clinical examinations. Where possible, this was done group-wise in the milking parlour, while on farms without a separate milking parlour, the goats were restrained with feeding yoke traps at the trough in their home pen. In the latter situation, all goats in the pen were restrained to prevent loose goats from directing aggressive behaviour towards restrained goats, and roughage was made available.

Before the physical examinations were conducted, a simple test to assess the goats' fear of unfamiliar humans was performed (chin contact test). The observer stood in front of each goat, reached out an arm with the palm pointing upwards, and gently moved the hand towards the goat's chin. The goat's response to the approaching hand was registered on a three-point scale: full acceptance; brief touch; or full avoidance (modified from B Whay, personal communication 2010).

While the observer was still positioned in front of the restrained goats, the head and neck region of all selected goats were examined, registering discharge from eyes and nostrils, mild or severe skin lesions, and damage to the ears due to ear-tags partially or totally ripped out. Parotid and sub-mandibular lymph nodes were palpated, and enlarged lymph nodes and intact or ruptured abscesses were registered. The observer then moved to the posterior end in order to examine the trunk, limbs and udder of each goat. Skin lesions were registered according to severity (mild or severe), and presence or absence of lice were recorded. Pre-scapular, pre-femoral, supra-mammary and popliteal lymph nodes were palpated, and enlargements or abscesses were recorded. Body condition score (BCS) was registered using 0.25 increments on a scale from 1 to 5 (modified from Villaquiran *et al* 2007), and chest girth was measured. The udder was inspected visually for conformation, asymmetry, impetigo and teat

doi: 10.7120/09627286.22.3.385

lesions, and carefully palpated for superficial fibrous nodules, abscesses and signs of acute clinical mastitis (eg heat, swelling or pain). Joints were palpated for swellings, and limbs were inspected for skin lesions, including carpal and tarsal callus formation. The feet were lifted to assess the degree of any claw overgrowth on a four-point scale. Finally, cleanliness of hindquarters and udder were registered.

The animals were subsequently released into their home pens, and the observer registered resource-based parameters, such as space per goat and air quality parameters, while the goats were present. The stockperson completed a questionnaire regarding management procedures, herd health status and behavioural attitudes, and this was collected before departure. Some attitudinal statements were modified from statements used in other studies (eg Hemsworth *et al* 2000; Lensink *et al* 2000), and most of the responses were requested on seven-point rating scales with descriptors for the extreme response categories. Time, outdoor temperature, light intensity and humidity were registered at arrival and departure.

Ambient temperatures and air humidity were measured with KIMO® HD100 Thermo-Hygrometers (KIMO®, Montpon, France) and draughts were measured using KIMO® VT100 Hot Wire Anemometers. Ammonia and carbon dioxide concentrations were measured with hand-held Dräger pumps (Drägerwerk AG & Co, KGaA, Lübeck, Germany) with Dräger colourimetric gas detector tubes (ammonia 5/a 5–70 ppm and carbon dioxide 100/a 100–3,000 ppm). Fluke 62 Mini Infrared Thermometers (Fluke Corporation, Washington, USA) were used to measure floor surface temperatures, and illuminance was measured using ST-1300 Light Meters (STANDARD Instruments Co Ltd, Kowloon, Hong Kong). The distances required to calculate the space allowances in the pens were measured with Leica Disto™ A3 laser distance meters (Leica Geosystems AG, Heerbrugg, Switzerland).

Data management and statistical analysis

The data were entered into Microsoft Office Excel 2007, where initial proof-reading and data management were conducted. Further data management and statistical analyses were performed with Stata/SE 11.0 (StataCorp, College Station, TX, USA). Inter-observer reliability of data collected in the final calibration exercise was assessed with percentage agreement and weighted kappa-values (Dohoo *et al* 2009) between pairs of observers.

New variables representing herd-level prevalence of the health variables were generated based on the observations of 20 animals per herd. Variables representing farm averages were generated for the resource-based parameters. Mean NH_3 and humidity were categorised to low (< 10 ppm/ < 70%), medium (10–19 ppm/70–80%) and high (>19 ppm/ > 80%) levels. To get three categories with sufficient observations of the questionnaire variable 'Importance of petting to succeed as a farmer', categories 1–4 (totally disagree — neutral), and 5 + 6 (agree) were aggregated, while 7 (totally agree) was kept as a separate category. For the question regarding how many goats were named, categories 1 + 2 (none or very few), 3 + 4 (some) and 5–7 (most or all) were aggregated. Index variables were created by adding scores of certain questionnaire variables thought to assess similar constructs. The index variable representing the reported frequency of watching and petting goats was subsequently categorised to 'frequently' (2–4), 'sometimes (5–7) and 'rarely' (8–14).

The association between the goats' responses and the farmers' approach behaviour in the handling test was initially assessed on individual-level data, using clustered robust generalised ordered logistic regression (due to violation of the proportional odds assumption) with farm as cluster variable. However, to avoid presenting a large number of estimates, the strength of the association was also assessed using a clustered robust linear regression model. Clustered robust partial proportional odds regression was most appropriate to identify predictors of the farmers' approach behaviour, while a proportional odds model was used to find predictors of the goats' fear of unfamiliar humans, both with farm as the cluster variable. Associations between herd-level variables were assessed using ordinary least squares linear regression, logistic regression or proportional odds regression. The assumptions for linear regression were tested with Q-Q plots, histograms of residuals and scatterplots for fitted values against residuals (Dohoo *et al* 2009). Linearity of predictor-outcome association was assessed with locally weighted scatterplot smoothing (Lowess) curves. Non-linearity was dealt with by categorising continuous predictors, as described. The assumption of proportional odds was tested with the Brant Test of Parallel Regression Assumption (Brant 1990), an approximate likelihood-ratio test (Wolfe & Gould 1998) or Wald's test (within the gologit2 command in Stata).

A liberal *P*-value is commonly used for the initial screening of independent variables in unconditional regression analyses to avoid omitting variables of which the effect only becomes evident together with other variables (Dohoo *et al* 2009). However, an in-depth exploration of all possible associations is beyond the scope of this paper due to the large number of variables. Thus, only predictors that were significant at the 0.05-level in unconditional regression models were considered for further analysis, and only strong associations that were unambiguous, biologically convincing or of particular interest in terms of animal welfare will be presented.

Results

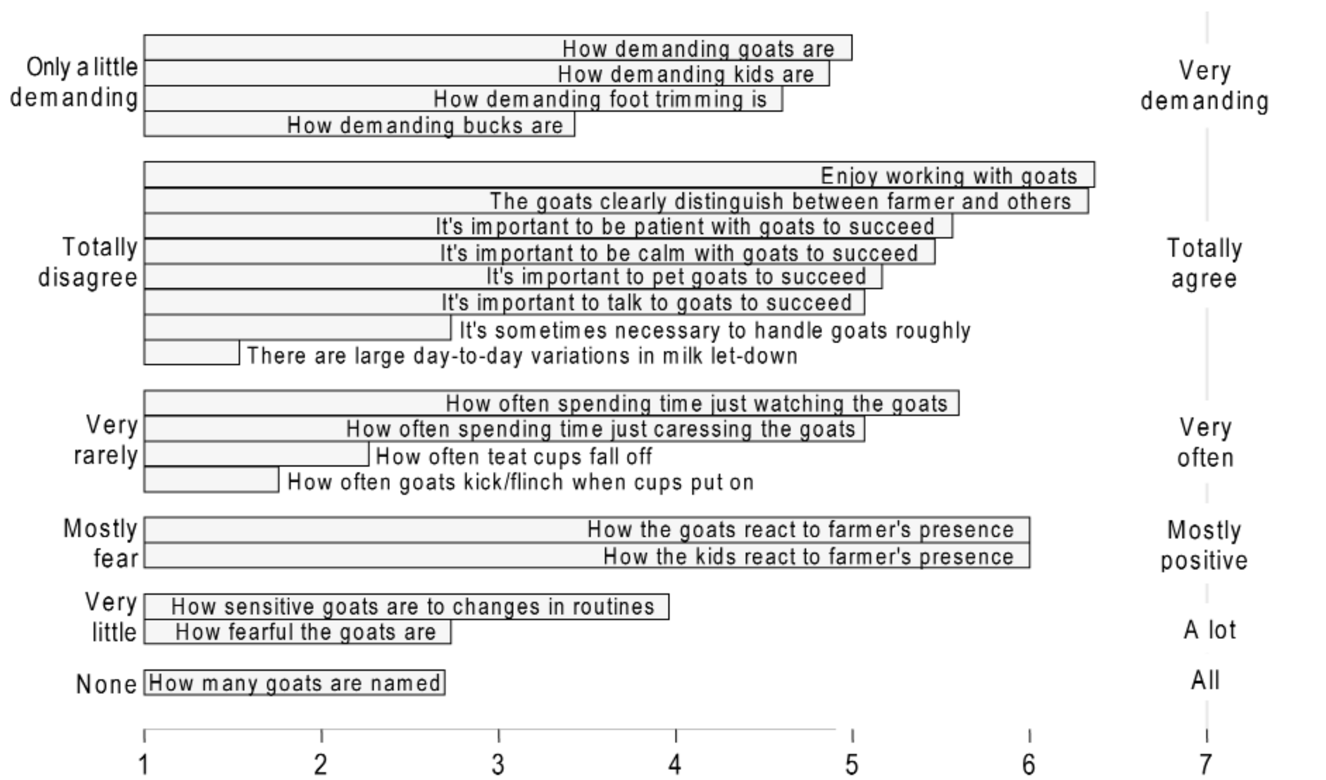
Table 1 illustrates how selected variables from the welfare assessment protocol are thought to cover the Five Freedoms.

The number of adult dairy goats on each farm ranged from 50 to 236, with a mean (± SD) of 98 (± 39.7) goats. On 13% of the farms (n = 4), the goats still had access to pasture at the time of the visit, and 23% (n = 7) of the farmers gave their goats some access to outdoor areas outside the pasture season. The time for drying off varied from the end of July to the end of December, and 30% of the farms (n = 9) had goats that were still lactating at the time the welfare assessment took place. The mean responses to the questions pertaining to behavioural attitudes, work motivation and general beliefs about their work as stockpeople are presented in the bar chart in Figure 1. Sixty percent of the

Table 1 Illustration of how selected variables in the protocol cover the Five Freedoms (FAWC 1993).

Freedom	Animal-based	Resource-based	Stockmanship and management	Registered data
1 Freedom from hunger and thirst: by ready access to fresh water and a diet to maintain full health and vigour	BCS Chest girth QBA	Roughage availability Feeder space (cm) Feed spaces (n) Goats per drinker		Milk yield
2 Freedom from discomfort: by providing an appropriate environment including shelter and a comfortable resting area	Overgrown claws Ectoparasites Ocular/nasal discharge QBA	Air quality Floor type Stocking density Temperature		
3 Freedom from pain, injury or disease: by prevention or rapid diagnosis and treatment	Skin lesions Lameness Swollen joints Swollen lymph nodes Udder pathologies Ocular/nasal discharge	Sharp protrusions Hygiene	Attitudes Approach in handling test	SCC Disease sanitation
4 Freedom to express normal behaviour: by providing sufficient space, proper facilities and company of the animal's own kind	QBA	Stocking density Group size Access to outdoor area Access to roughage	Age at weaning Kid rearing	Days on pasture
5 Freedom from fear and distress: by ensuring conditions and treatment which avoid mental suffering	Handling test Chin contact test QBA		Attitudes Time spent with animals Approach in handling test	

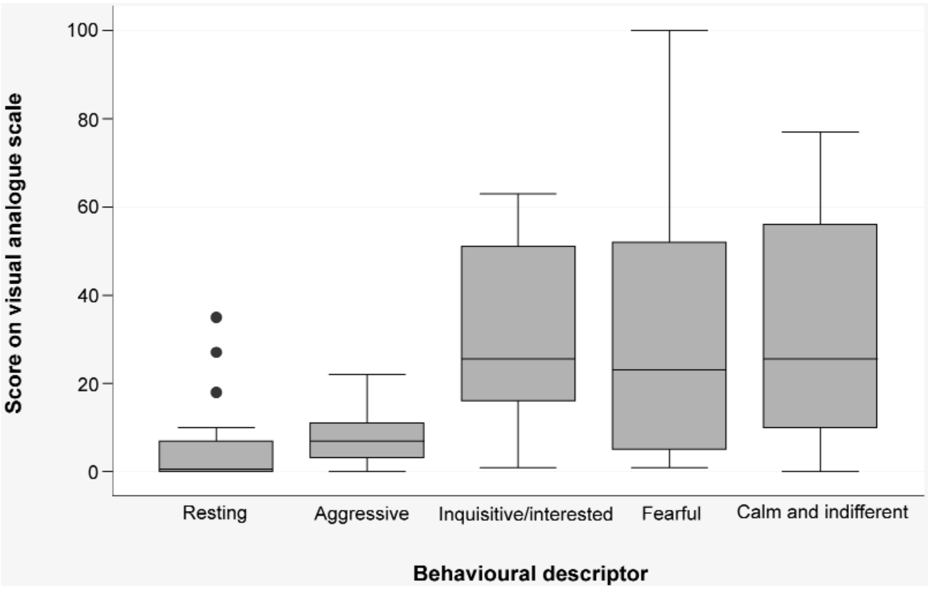
Figure 1



Mean responses to questionnaire items responded to on seven-point rating scales.

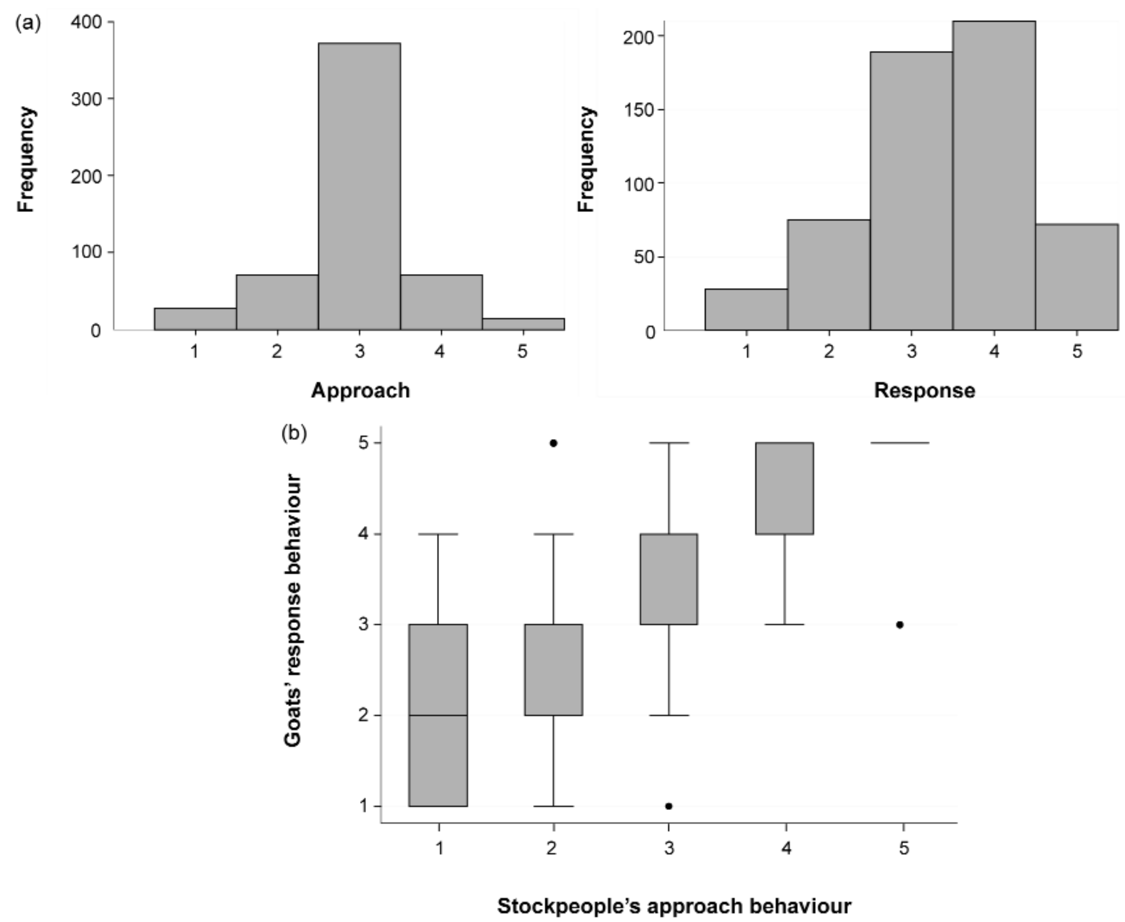
doi: 10.7120/09627286.22.3.385

Figure 2



Variation in scores of behavioural descriptors across farms as assessed by qualitative behavioural assessments of the whole dairy goat herd at 30 conventional farms.
The three points represent outliers.

Figure 3



Showing (a) distributions of approach behaviours and responses in the handling test, with the descriptors for the scoring categories (more details provided in the protocol), and b) box-plot presenting the association between approach and response behaviours. Approach: 1 Positive physical and verbal interactions; 2 Positive physical or verbal interactions; 3 Neither positive nor negative physical interactions (neutral), no verbal interactions; 4 Negative verbal interactions and/or mild negative physical interactions; and 5 Strongly negative physical interactions, with or without negative verbal interactions. Response: 1 Positive reaction, no fear; approaching stockperson immediately and initiating physical contact; 2 Somewhat positive reaction, no fear; approaching stockperson and initiating contact during the testing time; 3 Indifferent: Neither approaches nor avoids; 4 Mild fear: Attempts to avoid stockperson, but no panic; and 5 Strong fear/panic: Avoids immediately, difficult to catch.

farmers had attended a course in animal welfare, but none of them reported a high learning outcome. According to annual data from the Goat Milk Recording System for 2009 (n = 28), mean (± SD) milk yield per goat was 713 (± 126) kg, and mean (± SD) somatic cell count (SCC) was 863 (± 366) × 10^3 cells ml^{-1}.

On 18 of the farms there were abundant amounts of roughage left 1 h after morning feeding, while there was no food left on five farms. The scores of the five behavioural expressions registered during the qualitative behavioural assessment are presented in a box-plot in Figure 2. The distribution of the result of the handling test and the association between them are presented in Figures 3(a) and (b). The chin contact test showed that approximately 50% of the goats fully accepted being touched, 25% accepted a brief touch, while the remaining 25% fully avoided being touched.

The overall prevalences of the health parameters recorded during the clinical examinations of 20 animals on each farm are presented in Table 2. The variations in farm-level prevalences are presented as a box-plot in Figure 4. Chest girth measures ranged from 76 to 114 cm, with a mean (± SD) of 93.6 (± 6.1) cm. Mean (± SD) body condition score (combined lumbar and sternal scores) was 2.7 (± 0.2), and ranged from 2.0 to 4.0.

The resource-based parameters revealed large variations in measures such as area per goat, the number of goats per drinker, illuminance and gas concentrations (Table 3). Ten farms (33%) had more than one type of flooring material. Expanded metal was the predominant flooring type on 50% of the farms, while 20% (n = 6) and 17% (n = 5) predominantly had wooden and plastic slats, respectively. The goats were predominantly kept on deep litter on only 13% (n = 3) of the farms. Eleven farms had shelves for the goats to lie on. Outdoor temperatures at the farms ranged from –14.0 to 6.2°C, with a mean (± SD) of –2.4 (± 5)°C at the time of arrival.

The mean time taken to perform all the welfare registrations was 6 h 30 min, and ranged from 5 h 30 min to 7 h 30 min.

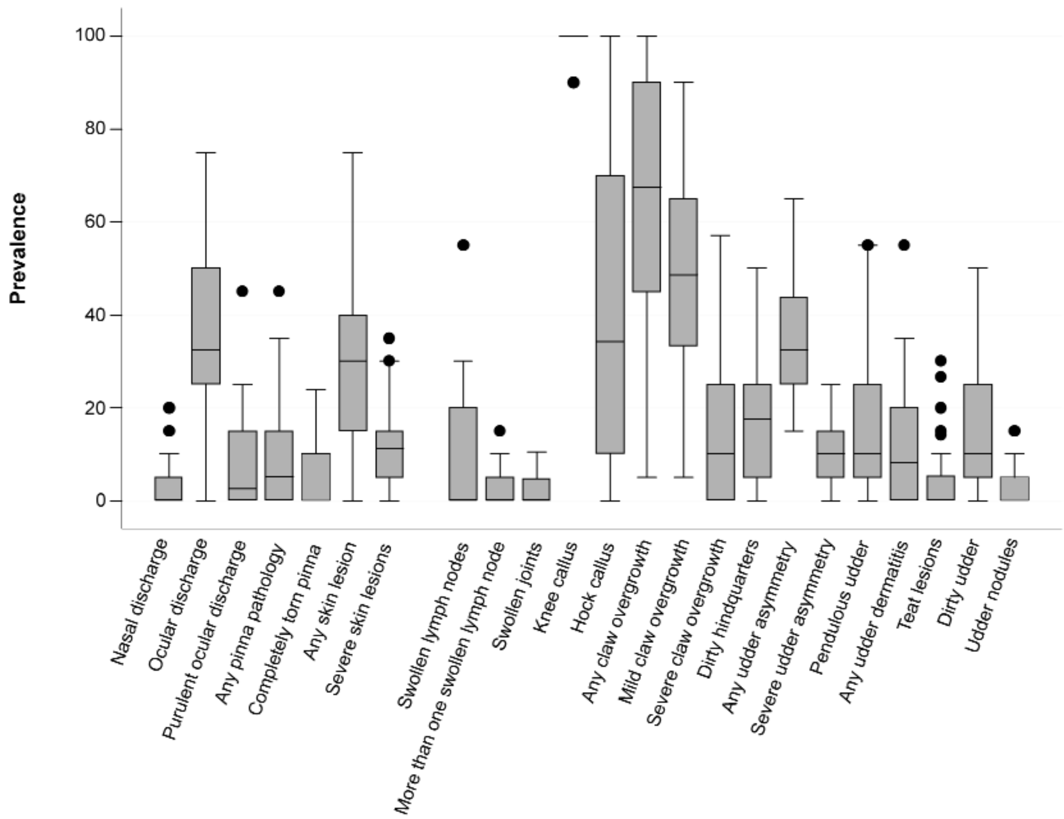
The regression coefficients, P-values and adjusted R^2 from all the models with behavioural and stockmanship variables as outcomes, are presented in Table 4. There was a strong association between farmers' approach and goats' response behaviours in the handling test, and indices of stockmanship were associated with four of the QBA descriptors. Table 5 presents the results of the regression analyses with health variables as outcomes. Ocular discharge was negatively associated with humidity level. Chest girth, hock skin changes and hindquarter hygiene were associated with different floor types. Ear damage and skin lesions were both negatively associated with the level of 'calm and indifferent' animals registered in the qualitative behavioural assessments. In addition, a proportional odds model showed that the mean NH_3 level was 1.6 times more likely to be in a higher category (P = 0.008) for every degree increase in temperature, while farms with one square meter more per goat were 0.02 times less likely to have NH_3 levels in a higher category (P = 0.05).

The tests of inter-observer agreement performed prior to the welfare assessments were mainly intended to improve the scoring categories and were therefore not suited to evaluate the reliability of the final protocol. However, the agreement between pairs of observers was on average above 90% for 16 of the health variables, and above 75% for 23 of them. For many variables, the average of the pair-wise weighted kappa values was less than moderate (κ ≤ 0.40), but for ten variables it was moderate (κ: 0.41–0.60) or better. The agreement was substantial (κ: 0.61–0.8) for mild and severe skin lesions on the trunk, and almost perfect (κ: 0.81–1.0) for pinna pathologies and udder conformation. In the data collected during the actual welfare assessments, a strong observer bias was discovered in the recordings of lice, so these data are not presented.

Table 2 Overall prevalence of health parameters among 597 goats from 30 dairy goat farms in Norway.

Parameter	N	Goats (%)	Farms (%)
Any nasal discharge	595	18 (3.0)	9 (30)
Purulent		4 (0.7)	4 (13.3)
Any ocular discharge	595	212 (35.6)	28 (93.3)
Purulent		44 (7.4)	15 (50)
Any pinna pathology	595	65 (10.9)	22 (73.3)
Complete ear tear		31 (5.2)	12 (40.0)
Lip lesions	595	2 (0.3)	2 (6.7)
Any skin lesions	597	181 (30.3)	29 (96.7)
Severe lesions		76 (12.7)	26 (86.7)
Enlarged lymph node	597	65 (10.9)	14 (46.7)
> 1 enlarged lymph node		13 (2.2)	8 (26.7)
Any udder asymmetry	596	205 (34.4)	30 (100.0)
Severe asymmetry		53 (8.9)	24 (80.0)
Missing gland		3 (0.5)	2 (6.7)
Pendulous udders	596	97 (16.3)	26 (86.7)
Clinical mastitits	594	2 (0.3)	2 (6.7)
Any udder dermatitis	596	71 (11.9)	21 (70.0)
Teat lesions	592	32 (5.4)	16 (53.3)
Any dirty udders	595	101 (17.0)	26 (86.7)
Very dirty udders		7 (1.2)	6 (20.0)
Udder nodules	593	17 (2.9)	10 (33.3)
Swollen joints	596	12 (2.0)	8 (26.7)
> 1 swollen joint		8 (1.3)	7 (23.3)
Knee callus	596	592 (99.3)	30 (100.0)
Hock callus	595	236 (39.6)	27 (90.0)
Any overgrown claws	593	395 (66.4)	30 (100.0)
Mild overgrowth		293 (49.4)	30 (100.0)
Severe overgrowth		88 (14.8)	21 (70.0)
Extreme overgrowth		12 (2.0)	7 (23.3)
Deformed claw		2 (0.3)	2 (6.7)
Dirty hindquarters	596	104 (17.5)	26 (86.7)
Diarrhoea	596	6 (1.0)	6 (20.0)
Any lameness	596	10 (1.7)	8 (27.0)

Figure 4



Variation in farm level prevalences of health variables from clinical examination of 20 adult dairy goats on each of 30 conventional farms. Points represent outliers.

Table 3 Farm average and range of resource registrations from pens with adult dairy goats.

Parameter	Observations	Farms	Mean	Range	Recommended
Number of pens	79	30	2.6	1–9	
Group size	79	30	58	11–173	
Area per goat (m^2)	78	30	1.0	0.6–2.1	1.5[b]
Number of feed spaces per goat	69	23	1.1	0.5–2.1	≥ 1
Feedspace (cm)[a]	72	29	34	18–42	
Goats per drinker	77	30	16	4–39	~ 10
Number of sharp protrusions	76	30	1.1	0–10	
Air temperature (°C)	163	30	8.1	–4.1–14.8	> 5–6[bc]
Floor surface temperature (°C)	162	30	7.3	–4.2–14.6	
Draught ($m\ s^{-1}$)	161	30	0.05	0.00–0.24	
Humidity (%)	156	30	75.4	53.4–95.0	< 70[c]/ < 80[bd]
Illuminance (lux)	177	30	87	20–300	≥ 100[c]/ ≥ 200[d]
CO_2 (ppm)	60	30	1,135	100–2,600	< 2,500[c]
NH_3 (ppm)	68	30	12	2–29	<10[c]/ < 25[d]
Pens with sleeping shelves (%)	79	30	36	0–100	
Pens with automatic feeders (%)	79	30	23	0–100	
Dirty pens (score 2) (%)	75	30	33	0–100	
Very dirty pens (score 3) (%)	75	30	6	0–100	

[a] Centimetres per vertically separated feed space. In pens with horizontal rail feed hurdle: cm per goat along the rail.
[b] Toussaint (1997); [c] Sevi et al (2009); [d] RSPCA (2010).

Table 4 Regression coefficients, *P*-values and explained variance of regression models with behaviour and stockmanship variables as outcomes. The coefficients for logistic models are the odds ratios.

Dependent variable	Independent variable	Regression coefficient	*P*-value	R^2/Adjusted R^2
Response[a] (Handling test)				0.34
	Approach (Handling test)	0.8	0.000	
Approach[b] (Handling test)				
	Some learning outcome	Baseline		
	No learning outcome	3.2	0.003	
Fear of non-familiar human[c]				
	Fearful (QBA)	1.2	0.001	
	Importance of petting; disagree	Baseline		
	Somewhat agree	0.9	0.534	
	Totally agree	0.3	0.000	
	Response (handling test): positive	Baseline		
	Neutral	1.3	0.223	
	Negative	2.1	0.000	
Fearful (QBA)[d]				0.15
	Naming none or very few	Baseline		
	Naming some goats	–22.0	0.061	
	Naming most or all goats	–32.4	0.026	
Calm and indifferent (QBA)[d]				0.18
	Naming none or very few goats	Baseline		
	Naming some goats	20.5	0.034	
	Naming most or all goats	27.8	0.020	
Inquisitive/interested (QBA)[d]				0.42
	Importance of petting: disagree	Baseline		
	Somewhat agree	12.2	0.072	
	Totally agree	38.0	0.000	
Aggressive (QBA)[d]				0.16
	Importance of petting: disagree	Baseline		
	Somewhat agree	–0.3	0.901	
	Totally agree	–6.6	0.027	
Resting (QBA)[d]				0.30
	Expanded metal	Baseline		
	Deep litter	14.8	0.001	
	Plastic slats	–0.7	0.856	
	Wooden slats	1.3	0.698	

[a] Clustered robust linear regression with farm as cluster variable.
[b] Clustered robust generalised ordinal logistic regression with farm as cluster variable: parallel lines constraints not imposed for not attending course (non-significant and not reported). Collapsed categories for Approach: 1 + 2 (positive) and 4 + 5 (negative).
[c] Robust clustered ordinal logistic regression with farm as cluster variable. Odds ratio calculated for an increase of 10 in the score of fearfulness. Collapsed categories for Response behaviours: 1 + 2 (positive) and 4 + 5 (negative).
[d] Ordinary least squares regression.

Table 5 Regression coefficients, *P*-values and explained variance of ordinary least squares regression analyses with herd level health prevalences or means as outcomes.

Dependent variable	Independent variable	Coefficient	*P*-value	Adjusted R^2
Any ocular discharge				0.27
	Humidity: < 70%	Baseline		
	70–80%	–23.4	0.006	
	> 80%	–22.7	0.004	
Any pinna pathology				0.25
	Calm and indifferent (QBA) < 15	Baseline		
	15–40	–10.8	0.029	
	> 40	–15.5	0.003	
Any skin lesions				0.20
	Calm and indifferent (QBA) < 15	Baseline		
	15–40	–12.3	0.117	
	> 40	–23.3	0.005	
Any hock skin change				0.34
	Expanded metal	Baseline		
	Deep litter	–33.4	0.042	
	Plastic slats	–6.2	0.676	
	Wooden slats	–29.6	0.033	
	Watch and pet: frequently	Baseline		
	Sometimes	18.2	0.172	
	Rarely	39.4	0.008	
Any dirt on udders				0.22
	Naming none or very few	Baseline		
	Naming some goats	–16.2	0.008	
	Naming most or all goats	–15.6	0.035	
Any dirt on hindquarters				0.36
	Expanded metal	Baseline		
	Deep litter	–3.6	0.596	
	Plastic slats	19.8	0.001	
	Wooden slats	3.1	0.542	
	Naming none or very few goats	Baseline		
	Naming some goats	1.6	0.769	
	Naming most or all goats	–13.0	0.020	
Mean BCS				0.39
	Attending welfare course	0.1	0.036	
	Automatic feeders	0.1	0.039	
	Still lactating	0.1	0.021	
Mean chest girth				0.42
	Expanded metal	Baseline		
	Deep litter	5.1	0.001	
	Plastic slats	3.6	0.009	
	Wooden slats	–1.3	0.299	

Discussion

The protocol was designed to assess the welfare of adult dairy goats during the winter housing period and prior to kidding. This study constitutes the only independent assessment of the welfare of dairy goats in Norway incorporating direct observations of the animals, and an examination of the relationships between welfare outcomes and husbandry provisions. The study also includes a first attempt to conduct qualitative behavioural assessments (QBA) of goats. The assessments could be performed during one working day, by a single observer. However, routine animal welfare assessments conducted by farm advisory services or by the authorities if animal-based criteria are included in future legislation, will likely need to be completed in less time, so continued work is required to make the protocol more feasible for that purpose.

Behaviour and stockmanship indices

Asking stockpeople whether or not they have attended a course in animal welfare (de Passillé & Rushen 2005) and using indices of stockperson attitudes that may predict their behaviour (Hemsworth *et al* 2009) have been proposed as alternative ways of auditing stockmanship due to reliability issues related to behavioural observations. This was the rationale behind addressing these aspects in a short questionnaire to the farmers as a part of the protocol. Certain behavioural attitudes did indeed appear to have the potential to predict welfare outcomes, but the mechanisms through which these effects are exerted are yet to be determined.

The qualitative behavioural assessments (QBA) enabled efficient registration of a few behavioural expressions, and research in other species suggests that the method can be applied reliably (eg Wemelsfelder *et al* 2000; Wemelsfelder & Lawrence 2001; Rousing & Wemelsfelder 2006). The significant associations found between QBA and measures of health and stockmanship are promising with regards to the future development of this method for goat welfare assessment. To our knowledge there is limited pre-existing evidence of associations between QBA and health variables, but mood-related expressions were found to be associated with lameness in sheep (Phythian *et al* 2011). Further research will determine the expressive repertoire that should be considered, and the reliability of QBA in the assessment of goat welfare.

'Fearful' was the behavioural expression with the greatest between-herd variation, with very high levels on some farms. Fear is a strongly aversive emotion and may also result in difficulties in handling, thus causing delays in detection of other welfare problems and an increased risk of injuries to both animals and stockpeople. Fear levels in ruminants may be related to genetic differences (Boissy *et al* 2005), but human-animal relationships have also been found to have lasting effects on temperament and behaviour (Boivin & Braastad 1996; Lyons & Price 1987; Lyons *et al* 1988; Lyons 1989). There were significantly lower scores of 'fearful' and higher scores of 'calm and indifferent' goats (QBA) in herds where the farmer had named larger numbers of the goats. We propose that naming a goat is a reflection of the quality of a specific human-animal bond. Developing such bonds requires that sufficient time is spent with the animals, which in turn may habituate the goats to the presence of humans and reduce general reactivity. Dairy cows have been found to be easier to approach and have higher milk yields in herds where the cows were given names (Bertenshaw & Rowlinson 2009), and this provides support to the relevance of including a question about naming animals. The protocol also identified that the farmers' attitudes towards petting their goats were negatively associated with the goats' fear of unfamiliar humans and the score of 'aggressive' (QBA), and positively associated with the score of 'inquisitive/interested' (QBA). This may suggest that goats that are accustomed to petting are less fearful and perhaps anticipate positive interactions in the presence of people in general. The score of 'resting' animals was generally very low, but was significantly associated with flooring type, with more resting animals on deep litter. This may have been confounded by the low temperatures at the time, as one study showed that goats preferred flooring materials with lower thermal conductivity in low ambient temperatures (Bøe *et al* 2007).

To our knowledge, there were no pre-existing behavioural tests for the on-farm assessment of stockperson-goat relationships, and the handling test presented may therefore be a useful starting point. However, once the stockpeople know that their behaviour is observed the interactions may become biased. A protocol should ideally be designed so that it can be used reliably on the same farm on more than one occasion, and transparency about the methods may be required when giving the farmers advice.

The goats' responses in the handling test and the score of 'fearful' (QBA) could to some degree predict the responses in the chin contact test, providing some evidence of construct validity. The avoidance (flight) distance test commonly used in other species has also been reported to be successful for assessment of goats' fear of humans (Mattiello *et al* 2010). However, we experienced problems with the use of this method during the development of the protocol, as on some farms a large number of the goats showed strong avoidance behaviour, whereas on other farms several goats would flock around the observer, making it impossible to perform the test in a standardised way. This suggests that the feasibility of behavioural tests may depend on breed differences in temperament, or production systems.

On most farms, the stockpeople had neutral approach behaviours in the majority of the interactions with the goats. The response behaviours of the goats were positively associated with the farmers approach in the handling test. There was a particularly clear tendency for strongly negative approach behaviours and high fear levels on one farm, suggesting that the quality of stockmanship needs to be addressed. However, these interactions are likely to be reciprocal; the more fearful the goats are, the more chasing may be required for the stockperson to approach and handle them, which in turn is likely to increase the animals' fear responses. Consequently, altering the human-animal relationships may require the stockperson's long-term effort. The farmers who had attended a welfare

doi: 10.7120/09627286.22.3.385

course and reported a poor learning outcome were more likely to use negative interactions than farmers who had some learning outcome, or farmers who had not attended a course at all. The farmers' perception of the course may be an indicator of their general attitudes to animal welfare, but it may also reflect on the aims and methods used in the courses they had attended. If courses are not tailored to alter specific attitudes in the stockpeople they are unlikely to result in the desired effect on their behaviour, and as such, the question of course attendance probably needs to be more specific.

Health

The protocol provided information about health issues that may need particular attention in the Norwegian dairy goat industry. The health variables overlapped with several of the variables included in a recently published UK study (Anzuino *et al* 2010). This suggests that there is some consensus among scientists and veterinary surgeons across different countries and systems regarding the welfare-relevance of goat health variables, and enables rough comparisons.

The most prevalent physical conditions observed in this study were ocular discharge, skin lesions, udder asymmetry, calluses on knees and hocks, and overgrown claws.

The majority of goats with ocular discharge only had mild symptoms. It is uncertain how important this is as a welfare issue, but it may indicate an underlying pathogenic challenge or a sub-optimal environment. Mild conjunctivitis may be part of an upper respiratory tract infection, commonly involving *Mycoplasma* spp (Harwood 2006). The inter-relationships between diseases and environmental factors are complex and related to effects on the survival of airborne pathogens, the dissemination and size of aerosol and dust particles, and effects on host resistance (Dennis 1986). Non-infectious causes of ocular discharge include dust, foreign bodies and entropion (Smith & Sherman 2009). The significantly higher prevalences of ocular discharge on farms with low relative humidity suggest that environmental factors like dust concentrations may play a role, but we did not measure the concentration of airborne particles.

There were significantly fewer animals with skin lesions and damaged ears due to ripped out ear-tags in herds with a higher score on 'calm and indifferent' (QBA), suggesting that some of the lesions are results of high levels of reactivity. Plastic flap-type ear-tags are most commonly used in Norway, and appeared to be least harmful in one study of sheep ears (Edwards & Johnston 1999). The goats are likely to experience pain as the tags are ripped out and for a varying period afterwards. In addition, the resulting lesions may provide entrance sites for pathogens, and may thus increase the risk of infections. The prevalence of ear damage due to ripped-out ear-tags in the UK study was approximately at the same level (6.2%) (Anzuino *et al* 2010).

It is generally acknowledged that mastitis is a painful condition (Fitzpatrick *et al* 1998; Hillerton 1998; Weary *et al* 2006; Fajt *et al* 2011; Muri & Valle 2012), which underlines the importance of good udder health variables in a welfare assessment protocol for dairy goats. Udder asymmetry was observed in a third of the examined goats and was the udder variable with the highest prevalence. There were 8.9% with severe asymmetry, which may have been caused by previous intra-mammary infections, or fibrosis due to chronic mastitis (Alawa *et al* 2000). Three goats (0.5%) had a missing gland, indicating a previous case of mastitis with gangrene and subsequent sloughing (Contreras *et al* 2003; Smith & Sherman 2009). The farms were in somewhat different parts of the production cycle, which may have affected the ease of detecting certain mammary conditions, such as fibrous nodules. Somatic cell counts (SCC) are known to be unreliable as indicators of subclinical mastitis due to variation caused by non-infectious factors (Bergonier *et al* 2003). This probably explains why we failed to find significant associations between herd-level SCC from the Goat Milk Recording System and any of the udder observations, and this limits the value of SCC as a potential welfare indicator.

Nearly all animals had knee calluses. Whilst the prevalence was somewhat lower in the UK study, the majority of animals were affected by knee calluses there too, despite the use of straw bedding (Anzuino *et al* 2010). This suggests that knee calluses are likely to appear regardless of flooring type. Hock calluses, on the other hand, were less prevalent than knee calluses, with a much greater variation between herds. Deep litter or wooden slats were associated with less skin changes on the hocks than expanded metal grating. In addition, stockmanship seems to play a role, as there were more hock skin changes in herds with farmers who rarely spend time petting or watching their goats.

It could be expected that claw overgrowth would be less of a problem in a system where expanded metal grating or slatted floors are predominant, in comparison with systems where goats are kept on straw bedding (Anzuino *et al* 2010). The prevalence of claw overgrowth in the current study was still high; indicating that the foot-trimming routines may need to be improved on many farms. However, the majority had only mildly overgrown claws. Lameness had a low prevalence (1.7%) and seems to be of much less concern than in the UK (19%). We experienced some difficulties in assessing gait in crowded pens where visibility was poor and in buildings with worn down wooden slats with widened gaps, which may affect the gait. Therefore, we assume that the true prevalence of mild lameness was somewhat higher than observed, but severe lameness cases have probably not gone unrecognised. The reliability of the four-point lameness scale needs to be further evaluated for goats, and alternative practical solutions should be considered to ensure the detection of mild cases.

Higher body condition scores were significantly associated with automatic feeders, but also welfare course attendance, which may suggest that feeding and nutrition is a common topic in these courses. The higher mean chest girth measures on farms with deep litter or plastic slats could suggest that these types of floor are more attractive to lie on, eg due to lower thermal conductivity or better isolation, thus leading to reduced energy expenditure. Higher chest girth measures have also been found to be associated with positive human handling of dairy goats (Jackson & Hackett 2007).

Resource-based measures

The resource-based measures were included to document the particular challenges inherent in the housing systems in the Norwegian dairy goat industry and to assess their associations with animal welfare outcomes. The list of measures is too exhaustive for routine welfare monitoring, but certain variables provide information that complement the animal-based measures, and would be necessary to include given the current legislation.

Despite the limited geographic distribution and the short time-period of data collection, temperature records ranged across almost 20°C, with indoor temperatures ranging from –4 to 15°C. The temperatures in Norway for November 2010 were record-low (on average 3.9°C below normal [The Norwegian Meteorological Institute 2010]), and the indoor temperatures may therefore not be representative for the time of year. A study of the performance of goat kids in uninsulated housing (Eik 1991) indicates that this species can perform well in lower temperatures than the recommended minimum (Table 3). However, experimental data suggest that goats reduce their lying time and increase the time spent eating in low ambient temperatures (Bøe *et al* 2007).

The failure of many farms to comply with recommended NH_3 and humidity levels can possibly be explained by the low temperatures, which may have lead farmers to reduce ventilation rates. Mean NH_3 levels were also positively associated with the stocking density and ambient temperature. In sheep, NH_3 levels from 15 ppm have been shown to result in reduced feed intake, increased sneezing and panting, as well as signs of pulmonary inflammation (Phillips *et al* 2011). Mean illuminance also failed to meet the recommendations. In addition to affecting the animals directly, poor lighting may limit the stockperson's ability to detect certain welfare problems. However, effects of most of these environmental measures on goat welfare have not been evaluated scientifically.

Experimental data have shown that a greater number of goats per drinker increases competition for water at feeding time, particularly if the ratio exceeds 30 goats per drinker, but some of the negative effects appear at an increase from 7.5 to 15 goats per drinker (Ehrlenbruch *et al* 2010). Competition for resources is known to cause increased levels of aggression and physical displacements among goats, affecting low-ranking animals most (Jørgensen *et al* 2007; Ehrlenbruch *et al* 2010). Thus, on the farms with highest goats/drinker ratios (up to 39 goats per drinker), there is a danger that particularly low-ranking animals may be prevented from drinking sufficiently to maintain optimal welfare, health and production.

The goats were by and large housed at higher stocking densities than recommended. Overcrowding may increase the risk of aggression and the spread of infectious diseases (Toussaint 1997). Reduced space allowance for goats has also been shown to be associated with a reduced lying time (Loretz *et al* 2004).

Reliability and validity

Both inter- and intra-observer reliability are of importance for welfare assessment protocols. For several variables, the inter-rater agreement data collected prior to the final adjustments of the protocol were not suitable for the statistical assessment of reliability, because the sample was too homogenous (either very high or very low prevalence). Similar problems with homogeneity have been described by Burn *et al* (2009). For other variables in our sample there was less homogeneity, and moderate to almost perfect reliabilities were achieved. However, because the assessment was intended as a calibration exercise and was used for final modifications to scoring categories, the reliability of the variables needs further testing. Furthermore, it has been argued that reliability should also be tested at farm-level, rather than just at individual animal level (Knierim & Winckler 2009). Future work should therefore involve a thorough evaluation of both inter- and intra-observer reliability of the final animal-based measures in a larger sample.

In many cases, validation of welfare indicators means testing the correlation against already validated and recognised welfare indicators. However, there are few existing validated indicators of goat welfare to correlate new indicators against, so future validation must be assessed in terms of convergence of conceptually related measures (Meagher 2009). The average herd sizes were relatively consistent with the average 92.6 goats per GMRS herd in 2010 (TINE Rådgivning 2011), and gives the results some external validity within the national goat population, albeit keeping in mind the selection criteria.

Animal welfare implications and conclusion

This study describes the development and testing of an on-farm welfare assessment protocol for dairy goats, and the welfare issues identified in 30 herds in which the protocol was tested. The protocol is comprehensive, and combines indicators of welfare outcomes and husbandry provisions to enable the identification of welfare problems, as well as shortcomings of the provisions that may affect welfare. The list of variables will probably need to be reduced and adjusted according to different production systems and the purpose of the welfare assessments. Specific health issues identified include ocular discharge, skin lesions, udder asymmetry and overgrown claws. Moreover, fear levels appeared to be of particular concern in some herds. Using behavioural observations to assess human-animal interactions remains a challenge, but the incorporation of indirect indicators of stockmanship in welfare assessments may partially compensate for this. There is a need to determine intervention thresholds and guides for each welfare indicator, so that advice can be tailored to the specific welfare issues identified on each farm.

In conclusion, we believe that the experiences gained in this study could contribute to the development of a much-needed welfare assessment protocol for dairy goats.

doi: 10.7120/09627286.22.3.385

Acknowledgements

The authors are particularly grateful to all the farmers that welcomed us to their farms, either to test early versions of the protocol, to practice the assessment methods or for the actual data collection. We thank N Leine for immensely valuable advice regarding goat health and welfare, and for helping to test early versions of the protocol. We thank HG Tønnesen and A Welcome for assistance in testing the protocol and data collection, and HG Tønnesen also for punching data. We would also like to thank Dr HR Whay for kindly letting us use a modified version of the chin contact test from her unpublished work. We also wish to thank Dr IL Andersen for suggestions regarding the assessment of human-animal interactions, and we thank the project 'Kubygg' for lending us the equipment for recording environmental parameters. Finally, we wish to thank the anonymous referees for valuable feedback. This work was funded by a grant from the Research Council of Norway (project nr 179745 NORDAM-SAM) and by TINE SA.

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