UNIVERSITÀ DEGLI STUDI DI MILANO

Dipartimento di Scienze veterinarie e sanità pubblica

Scuola di Dottorato in Sanità e produzioni animali: scienza, tecnologia e biotecnologie

Dottorato di ricerca in Produzioni animali - curriculum Etologia applicata

XXV ciclo

ANIMAL-BASED INDICATORS FOR ON-FARM WELFARE ASSESSMENT IN CATTLE AND GOATS

AGR/19

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A.A. 2012/2013

Alla mia famiglia,

unica e meravigliosa

The greatness of a nation and

its moral progress

can be judged by

the way its animals are treated.

Gandhi

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General Abstract

Animal welfare is a scientific discipline in continuous development and updating, motivated by the increasing concerns from the European citizens.

Recent researches highlighted the importance of the use of animal-based indicators to assess and evaluate the actual welfare status of farmed animals. Moreover, indicators should be feasible (concerning time and money consumption), as well as being valid and reliable.

Many welfare assessment protocols have already been developed for various farmed species, such as cattle, pigs and poultry, but they still require refinement and deeper studies, in order to adapt the way of data collection to different situations, giving more appropriate results.

In Chapter 1, the aim of the study was to investigate the long-term stability of two behavioural tests (Avoidance Distance – AD; Avoidance Distance at the Feeding rack – ADF) used to evaluate the human–animal relationship, in order to refine on-farm welfare assessment protocols for dairy cattle and to adapt them to alpine husbandry systems. Fifty lactating cows were tested three times (before grazing period – bg; during grazing period – dg; after grazing period – ag) during a year, following their management changes (indoor period *vs* outdoor summer grazing). Values of AD ag (113.93 ± 21.21 cm) were significantly higher ($P < 0.05$) than those observed in AD bg (71.07 ± 14.63 cm) and in AD dg (77.68 ± 18.11 cm). A similar trend was recorded also for ADF, which was significantly higher after the grazing period (ADF bg *vs* ADF ag: 25.00 ± 6.80 *vs* 47.50 ± 8.72 cm; $P < 0.05$). For certification purposes, the effect of summer grazing period should be borne in mind, as it may affect the reaction of cows towards humans.

In Chapter 2, the aim of the investigation was to compare the prevalence of welfare indicators (integument alterations, lameness and malformations) of poor welfare in 612 dairy cows among five Italian cattle breeds with different milking production and selective pressure (local breeds *vs* high selected breeds) kept in tie-stalls in the Italian Alps under similar housing and management conditions. The local breeds presented a significantly lower prevalence of all the considered variables compared with the other more productive and selected breeds ($P < 0.001$). The effect of the breed significantly affected the welfare of dairy cows in tie-stalls in alpine traditional husbandry systems, as the prevalence of the negative welfare indicators studied was lower in local breeds, which were better adapted to local farming conditions.

In addition to the refinement required for indicators on already investigated farmed species, the EU commission is presently requiring to develop welfare assessment protocols considering other farmed species in European countries not yet covered by previous research projects, such as small ruminants (sheep and goats), other poultry (turkeys) and equines (horses and donkeys).

In order to answer to this request, we concentrated on goats and, in Chapter 3, a literature review on animal-based indicators for this species was carried out to gather information about promising indicators to be included into an on-farm welfare assessment protocol. Indicators were classified into four principles and twelve criteria. Twenty-five promising indicators were found, but in many cases actions are still required in order to assess their validity, reliability and feasibility. As expected, indicators related to health and disease are the more represented. Adult dairy goats are widely considered, as they represent the main category bred in Europe. More studies are needed in order to confirm the already existing results and to improve the development of effective on-farm welfare assessment protocols.

In Chapter 4, the study investigated the feasibility in goats of an avoidance distance (AD) behaviour test set-up for cattle, and compared the results in the two species to assess the suitability of the test for on-farm evaluation of human-animal relationship in goats. The tests were performed on 324 lactating cows and 271 lactating goats, housed in free stall farms. Goats exhibited a higher level of confidence with humans, as showed by lower AD (goats: 68.60±4.98 cm; cows: 71.36±4.37 cm; $p < 0.10$) and higher frequency of contacts with the observer (goats: 45.8%; cows: 31.2%; $p < 0.001$). The AD test seemed feasible in goats, but its sensitivity needs to be improved, considering the different interactions of goats towards humans, compared to that of cows.

In Chapter 5, the aim of the study was to gather information about the possibility of using the hair condition in goats as welfare indicator. This experiment was initially performed in Portugal, and then repeated in Italy, in order to increase the sample size and to test the validity of this indicator in different farming conditions. The results were comparable between the two repetitions and will therefore be presented together. Two homogeneous groups of 24 adult dairy goats with bad hair (RH: rough or scurfy hair) and 24 goats with good hair (NH: shiny and sheen hair) were subjected to general clinical inspection, evaluation of body condition score, hair and blood collection for the analysis of mineral content, inspection for the presence of abscesses, faecal sampling for the analysis of endo-parasites and skin inspection for the presence of ecto-parasites. Nutritional and health conditions were poorer in BH, compared to that of GH. Too thin goats were present with higher prevalence in BH (BCS at sternum area, $p < 0.01$; BCS at lumbar area, $p < 0.001$). BH also showed a higher prevalence of abnormal lung sounds ($p < 0.001$), compared to GH. Preliminary results are encouraging to state that the hair condition can be a valid and feasible indicator of goat welfare.

The studies presented show the complexity of the animal welfare discipline. Many results have been achieved, but further efforts need to be accomplished in order to reduce errors in the welfare assessment.

Introduction

Concerns for animal welfare are constantly growing in European citizens and consumers (Blokhuis et al., 2003; Miele and Parisi, 2001), but the interpretation of the concept of animal welfare differs considerably among countries and people (Te Velde et al., 2002; Vanhonacker and Verbeke, 2007). Over the years, cultural, attitudinal and commercial issues have influenced the communication between farmers and customers (Blokhuis, 2009). In general, the awareness but also a sort of scepticism about animal welfare seem to have increased since the early 1990s (EFSA Journal 2012a; Kjærnes and Lavik, 2007). It was for the first time in 2006, that the Community Action Plan on the Protection and Welfare of Animals (2006-2010) collected the various aspects of the EU policy on the welfare of animals' farming for economic purposes (Action Plan, 2006-2010). The recent Action Plan (2012-2015) is still on-going as a continuation of the Action Plan 2006-2010 as recommended by most stakeholders. Five main areas of action have been set out to introduce a EU legislative background related to animal welfare, taking into account: upgrading minimum standards for animal welfare; promoting research and alternative approaches to animal testing; introducing standardised animal welfare indicators; better informing animal handlers and the general public on animal welfare issues; and supporting international initiatives for the protection of animals.

Animal welfare is a scientific discipline, hence well-targeted research is crucial for the development of effective policies to ensure the protection and welfare of animals (Action Plan, 2012-2015). In particular, animal welfare is a multidimensional discipline and a wide variety of measures should be applied (Blokhuis et al., 2006). Since 2001, different welfare monitoring systems have been developed in Europe, mainly based on environmental observations, e.g., animal welfare index TGI35L in Austria (Bartussek, 2001; Seo et al., 2007) and TGI200 in Germany (Sundrum et al., 1994). However, the link between specific environmental measures and the animals' welfare status is not completely clear (Blokhuis et al., 2006). It is known that resource- and management-based measures consider the risk factors that might affect welfare more than their direct effects on the animals (Keeling, 2009), so the actual animal welfare cannot properly be evaluated (Blokhuis et al., 2006; EFSA, 2012a; EFSA, 2012b). It is important to remember that animals may perceive the experience of the same housing situation or handling procedure in different ways (Keeling, 2009). This change in approaching animal welfare assessment led to protocols mainly focused on animal-based indicators in many farm species, such as cattle, including dairy cows, beef bulls and veal calves (Capdeville and Veissier, 2001; Forkman and Keeling, 2009a; Popescu et al., 2010; Popescu et al., 2011; Gottardo et al., 2009; Rouha-Mulleder et al., 2010; Tosi et al., 2001; Welfare Quality® Protocol, 2009a); pigs, including sows, piglets and fattening pigs (Forkman and Keeling, 2009b; Nakamura et al., 2011; Velarde and Geers, 2007; Welfare Quality® Protocol, 2009b; Welfare Quality® Protocol, 2009c); poultry, such as broiler chickens and laying hens (Algers and Berg, 2001; Arnould and Butterworth, 2010; Forkman and Keeling, 2009c; Welfare Quality® Protocol, 2009d;); and buffaloes (De Rosa et al., 2005).

According to the more pressing demands from the EU commission, systems already developed are still requiring further enlargement and refinement. Moreover, other important farmed species should be investigated, such as small ruminants (sheep and goats), poultry species not covered yet (such as turkeys) and equines (horses and donkeys).

During the PhD period, I took into account different issues related to the refinement of existing welfare assessment protocols for dairy cattle and to the development of a welfare assessment protocol for goats.

The long-term stability of indicators (Brule et al., 2007; Corazzin et al., 2010; Winckler et al., 2007) is frequently ignored. However, this issue may seriously affect the outcome of a welfare protocol, especially when management and environmental conditions change throughout the year. This is the case, for example, in traditional alpine husbandry systems. Therefore, in Chapter 1 we present the results of a research aiming at verifying the long-term stability of Avoidance Distance tests for the evaluation of the Human-Animal Relationship in those husbandry systems (Battini et al., 2011).

As already stated, the use of animal-based indicators seems the more appropriate tool to achieve the objective of assessing the actual state of animals (Blokhuis et al., 2006; EFSA, 2012a; EFSA, 2012b; Keeling, 2009). For example, the welfare level of different cattle breeds housed under similar conditions may widely differ. This was tested in Chapter 2 in five different cattle breeds housed in tie-stalls (Mattiello et al., 2011).

Due to the need of improving the research on farmed species not yet considered in actual existing protocols, literature has been reviewed to collect and highlight promising animal-based welfare indicators for goats. The outcome of this literature review are presented and discussed in Chapter 3.

Among the possible indicators to be included in a welfare assessment protocol for goats, human–animal behaviour tests are certainly important. The methods adopted so far to test these relationship are often valid, but not always practical and feasible on-farm. Therefore, we tried to set up a valid and feasible method starting from the Avoidance Distance test set up for cattle. We applied it to both goats and cattle and compared the results, which are presented in Chapter 4 (Mattiello et al., 2010).

Finally, another promising indicator of goats' welfare, highlighted from our review, was hair condition. In Chapter 5, we set up an experiment, which was carried out partly in Portugal and partly in Italy, to validate this indicator.

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Chapter 1

LONG-TERM STABILITY OF AVOIDANCE DISTANCE TESTS FOR ON-FARM ASSESSMENT OF DAIRY COW RELATIONSHIP TO HUMANS IN ALPINE TRADITIONAL HUSBANDRY SYSTEMS

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Published in: Applied Animal Behaviour Science 135 (2011): 267– 270

A B S T R A C T - The present study investigates the long-term stability of two behaviour tests used to evaluate the human–animal relationship as well as gather information to refine on-farm welfare assessment protocols in alpine husbandry systems. Two tests, Avoidance Distance (AD) and Avoidance Distance at the Feeding rack (ADF) were performed on 50 lactating cows, bred in a loose housing system, following a protocol validated for dairy cows in the Welfare Quality® project. AD was performed on each animal at three different times: at the end of the indoor housing period just before the grazing period (AD bg); during the outdoor summer grazing period in mountain ranges (AD dg); and at the beginning of the indoor housing period, just after the grazing period (AD ag). ADF was performed on the same cows only during the housing period, at the bottom of the valley, before (ADF bg) and after (ADF ag) the grazing period. Values of AD ag (113.93 ± 21.21 cm) were significantly higher ($P < 0.05$) than those observed in AD bg (71.07 ± 14.63 cm) and in AD dg (77.68 ± 18.11 cm). No statistical significance was pointed out between AD bg and AD dg. A similar trend was recorded also for ADF, which was significantly higher after the grazing period (ADF bg *vs* ADF ag: 25.00 ± 6.80 *vs* 47.50 ± 8.72 cm; $P < 0.05$). The summer grazing period seems to affect the reaction of cows towards humans, and AD and ADF are not consistent throughout the year. Certification of on-farm welfare in alpine husbandry systems, therefore requires performing these tests at the end of the indoor period, to gain better insight of the human–animal relationship for the environment in which cows live most of the year.

Keywords: dairy cattle**,** human–animal relationship**,** avoidance test**,** long-term stability**,** alpine husbandry

INTRODUCTION

The human–animal relationship (HAR) can be defined as the degree of relatedness or distance between the animal and the human, i.e. the mutual perception (Estep and Hetts, 1992). It has been proven that the quality of HAR can considerably affect animal welfare (for review: Rushen et al., 1999a; Boivin et al., 2003; Waiblinger et al., 2006). Many procedures (veterinary treatments, restraint, depopulation, etc.), in current farm practice negatively affect HAR, while few interactions such as feeding are positively reinforced. The stockperson's behaviour is a major variable determining the animal's fear of or confidence in human beings (Hemsworth et al., 1993). Negative experiences have a number of undesirable consequences for livestock, farmers and consumers such as for example in dairy cattle, reduced milk yield or milk let down (Seabrook, 1972; Knierim and Waran, 1993; Rushen et al., 1999b; Breuer et al., 2000; Waiblinger et al., 2002). Human–animal behaviour tests are important parameters to include during on-farm welfare assessment protocols (Hemsworth et al., 2000; Boivin et al., 2003; Waiblinger et al., 2006). These tests have been reviewed recently by Waiblinger et al. (2006). In particular, reactions to a moving human by avoidance distance tests are good indicators of HAR (Windschnurer et al., 2009a) and they have been already validated in previous studies (Waiblinger et al., 2002). The assumption of these tests is that the motivations to avoid or approach a human are opposite, but the animal's possible fear of the stimuli will have a major influence on the animal's behavioural response (Hemsworth and Coleman, 1998). Avoidance distance from a person is supposed to reflect previous experience of animals with humans and is defined as the distance that an animal allows a moving person to approach (Sambraus, 1974; Grandin, 1987; Purcell et al., 1988; de Passillé and Rushen, 2005). Approach behaviour is interpreted as the level of fear of man due to experiences of positive or negative handling and is defined as the animal intends to approach a stationary person (Hemsworth and Coleman, 1998; de Passillé and Rushen, 2005). Studies by Waiblinger et al. (2002, 2003) conclude that avoidance distance of cows towards a human properly reflect the HAR and that this accounts partly also for the approach behaviour. Since both avoidance distance test in the stable or in open pasture and avoidance distance test at the feeding rack have been validated in previous studies to rightly reflect the HAR, some authors state that the social agonistic behaviour may also affect avoidance distance tests at the feeding rack (Waiblinger et al., 2003). An important aspect of on-farm welfare assessment has to deal with the long-term stability of the indicators, which are tested at different times in a considered period and give information about potential changes. The question as to how representative single recordings are with regard to potential changes throughout the time then arises. If welfare assessment protocols are used for certification purposes with infrequent or even single assessments, the representativeness of recordings with regard to the long-term situation on the farm becomes especially important (Winckler et al., 2007). The consistency throughout the year of a welfare assessment protocol is particularly relevant in a traditional alpine husbandry system with periodical management changes. Dairy cows are housed indoor during the cold season and are taken to mountain ranges for a grazing period during summer. We may therefore hypothesise that environmental and management changes, deriving from this husbandry practice, may lead to modifications in the animal responses towards human. The present study investigates the longterm stability of avoidance distance tests in alpine husbandry systems, in order to gather useful information for refining these on-farm welfare assessment protocols.

MATERIALS AND METHODS

The study was conducted in the Province of Sondrio (Central Alps, Italy) on 50 lactating dairy cows (mean age: 6 years; range 3–14 years). Cattle breeds were Brown Swiss, Italian Bruna and Italian Holstein Friesian. The animals were bred in loose housing system at the bottom of the valley, during the indoor period, from October to May, and then were transported by truck to alpine ranges during the outdoor period in summer, from June to September. During the summer ranging period, the cows had free access to pasture day and night, but they were provided with adequate shelter, in case of adverse weather conditions. During the indoor housing period, cows were fed with roughage and concentrate twice a day (07:00–19:00 h). During the outdoor period, no feed supplement was provided and animals grazed on fresh grass only. Since milking routine can affect the HAR, and thus modify the avoidance distance, only cows that were being milked for the whole research period were considered. The mechanic milking was performed with the same routine by the same person twice a day, both indoor and outdoor. Avoidance Distance test (AD) was performed three times on each animal at three different moments, by a single observer: (1) at the end of the indoor housing period, in May, just before the grazing period (AD bg); (2) during the summer grazing period on mountain ranges, in July (AD dg); (3) at the beginning of the indoor housing period, in October, just after the grazing period (AD ag). Furthermore, during the indoor housing period, the Avoidance Distance test at the Feeding rack (ADF) before (ADF bg) and after (ADF ag) the summer grazing period was also performed on the same cows. AD and ADF to an unknown person were performed following a protocol validated for dairy cows in the Welfare Quality® project (Windschnurer et al., 2009b). In AD, the observer, previously trained, entered the home pen or reached the animal in mountain ranges, and stood in front of the animal at a distance of 300 cm, establishing a reciprocal visual contact with the animal; then the observer started moving slowly towards the animal at a speed of one step/s, 60 cm/step and the arm lifted with an inclination of 45°, the hand palm directed downwards, without looking into the animal's eyes, but looking at the muzzle. When the animal showed the first avoidance reaction (moving backwards, turning or shaking its head), the observer recorded the distance from his hand and the muzzle of the animal, estimated by sight with a definition of 10 cm. The accuracy of the estimate had been previously assessed during the training period. If the animal could be touched by the observer, the distance was 0. ADF was similar to AD with the observer standing at a distance of 200 cm in front of the cow, while the animal was at the feeding rack, 5–10 min after feed distribution. Cows were not restrained during the feeding times. Data with the Shapiro–Wilk test did not satisfy assumptions of a normal distribution. Data were thus analysed using non-parametric analysis of variance (matched pairs Wilcoxon test; SPSS 16.0, 2007), in order to test the effect of management changes on cow reaction to human approach. Each animal served as its own control, so the effect of individual reactions was not considered. Results are reported in Tables 1 and 2.

RESULTS

Results are reported in Tables 1 and 2. Significant variations were found both for AD and ADF depending on changes in management. AD was significantly higher after the grazing period than before or during this period (AD bg *vs* AD ag and AD dg *vs* AD ag: $P < 0.05$). No statistical significance was pointed out in AD bg *vs* AD dg. A similar trend was recorded also for ADF, which was significantly higher after the grazing period (ADF bg *vs* ADF ag: $P < 0.05$). Only for AD bg, were distances recorded below the maximum (250 cm).

Test	Mean±s.e. (cm)	Minimum distance (cm)	Maximum distance (cm)
AD bg	71.07 ± 14.63	0	250
AD dg	77.68 ± 18.11	0	300
AD ag	113.93 ± 21.21	0	300

Table 1 - Table showing the values of avoidance distance recorded before (AD bg), during (AD dg) and after (AD ag) the grazing period. The table reports the mean ± standard error and the minimum and maximum (cm) observed values.

Test	Mean ± s.e. (cm)	Minimum distance (cm)	Maximum distance (cm)
ADF bg	25.00±6.80	0	200
ADF ag	47.50±8.72	0	200

Table 2 - Table showing the values of avoidance distance recorded at the feeding rack (ADF) on farm, before (ADF bg) and after (ADF ag) the grazing period. The table reports the mean ± standard error and the minimum and maximum (cm) observed values.

DISCUSSION

In the present study, a lack of consistency in cow responses to both AD and ADF in traditional alpine husbandry systems was recorded. The results both for AD and ADF show the same trend, in relation to the management changes, even though other authors state that social behaviour could affect ADF (Waiblinger et al., 2003). The summer grazing period affects the reaction of cows towards humans, although this effect is not immediately perceptible. In fact, AD dg does not differ from AD bg recorded indoor at the beginning of the grazing period, though the maximum distance recorded in AD bg (250 cm) is below the avoidance distance in AD dg (300 cm). After the grazing period, the avoidance distance is significantly higher than both AD bg and AD dg. Consistently, ADF ag is higher than ADF bg, too. In our study, in spite of the wide possibility of movement in alpine ranges, AD dg remains as low as before the grazing period, probably because the level of confidence with man is still affected by the frequent contacts during the previous indoor period. However, when cows come back from the outdoor period, after four months at pasture, they are less confident with humans. This means that, after a latency period, some changes occurred in the avoidance distance response of the cows, and differences in both AD and ADF can be recorded between the two measurements in the same indoor situation, before and after the grazing period. These results differ from what was reported by Winckler et al. (2007), who tested cubicle-housed dairy herds five times at two-month intervals, finding good consistency over time. De Rosa et al. (2003) also found a high degree of repeatability of avoidance distance in both dairy cows and buffaloes. The lack of consistency in our study is probably due to the management changes during the year, in this type of husbandry system, whereas in the other studies the management was regular throughout the year. In our situation, one of the main factors affecting AD and ADF is the different management of animals, as well as the frequency of human–animal interactions, between indoor and outdoor period. In fact, the quality and quantity of these interactions are regarded as the main determinants of the resulting HAR (Boivin et al., 2003; Hemsworth et al., 2000; Waiblinger et al., 2006). During the summer grazing period, the frequency of contacts with humans is lower, as interactions are limited to only milking operations whereas during indoor periods feeding and cleaning operations are also performed every day.

CONCLUSIONS

In the present study, AD and ADF are not consistent throughout the year because of the peculiarity of traditional alpine husbandry systems, during which some important changes in the quality and the quantity of HAR occur. Welfare assessment protocols should therefore take into account possible modifications in the response to human approach, as a result of management changes, and clearly specify the best time to perform AD or ADF in order to obtain the most representative information. For certification purposes, in alpine husbandry systems, welfare assessment should be performed before the summer grazing period, reflecting the HAR during the indoor period and the situation in which cows live during most of the year.

ACKNOWLEDGEMENTS - We are grateful to all the farmers who collaborated with this research and to the Farmer's Association of the Province of Sondrio (APA) that helped us contact the farmers. Special thanks also to Elisabetta Canali, Michela Minero, Valentina Ferrante and Daniela Baroli for sharing their knowledge of the Welfare Quality® project and the training of the observer.

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Chapter 2

BREED DIFFERENCES AFFECTING DAIRY CATTLE WELFARE IN TRADITIONAL ALPINE TIE-STALL HUSBANDRY SYSTEMS

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Published in: Journal of Dairy Science 94 (2011): 2403–2407

ABSTRACT - The aim of this investigation was to compare the prevalence of indicators of poor welfare among 5 Italian cattle breeds (Italian Holstein-Friesian, Italian Bruna, Pezzata Rossa Italiana, Grigia Alpina, and Pezzata Rossa d'Oropa) kept in tie-stalls in the Italian Alps under similar housing and management conditions. We recorded the presence of integument alterations (hairless patch areas, lesion/swollen areas, or overgrown claws) and lameness in 612 cows. Additionally, we checked 834 cows for the presence of physical malformations ("open" shoulders). In general, the prevalence of welfare problems showed a decreasing trend from the more productive to the less productive breeds. Local breeds (Grigia Alpina and Pezzata Rossa d'Oropa) showed a significantly lower prevalence of welfare problems compared with the other 3 breeds, whereas Italian Holstein-Friesian usually had the highest percentage of individuals with problems. No differences were found between Pezzata Rossa Italiana and Italian Bruna, both of which showed fewer problems than Italian Holstein-Friesian. The effect of the breed significantly affected the welfare of dairy cows in tie-stalls in alpine traditional husbandry systems. The prevalence of the negative welfare indicators studied was lower in local breeds, which are better adapted to local breeding conditions. Our results indicate an urgent need to promote changes in the criteria used for genetic selection in the dairy industry and underline the importance of maintaining the diversity of local breeds, which should be carefully chosen for each specific environmental condition.

Keywords: dairy cattle breed, tie-stall, alpine husbandry system, animal welfare

INTRODUCTION

In the Italian Alps, dairy cattle are usually housed in tie-stalls during the cold season (Bovolenta et al., 2008). It has been recognized by many researchers (e.g., Bloom, 1983; Valde et al., 1997; Mattiello et al., 2005) that the housing of cattle in tie-stalls may result in several problems in terms of welfare. Among them, we can find an increased risk of lameness, of podal and body lesions (Bloom, 1983; Bielfeldt et al., 2005), and of physical malformations (e.g., "open" shoulders; Mattiello et al., 2009). These considerations are clearly expressed in the European Food Safety Authority (EFSA) Scientific Opinion on the overall effects of farming systems on dairy cow welfare and disease (EFSA, 2009a), which negatively rates the effects of housing in tie-stalls and even includes a minority opinion stating that "there is sufficient evidence for poor welfare in dairy cattle held in tie-stalls. It is recommended that dairy cattle should not be routinely kept in tie-stalls as a housing system." However, tie-stalls are traditional husbandry systems in the Italian Alps and some local breeds have been bred under these conditions for a long time; therefore, we hypothesize that different cattle breeds can show different levels of adaptation to this housing system. The aim of this investigation was to compare the presence of some indicators of welfare (such as injuries or physical malformations) in 5 Italian cattle breeds housed in tie-stalls in the Italian Alps. We visited 44 farms located throughout the Italian Alps: 18 farms in Piedmont (Western Alps), 14 farms in Lombardy (Central Alps), and 12 farms in Alto Adige (Eastern Alps) and collected individual data on 612 cows of different breeds: 94 Italian Holstein-Friesian (F), 125 Italian Bruna (B), 79 Pezzata Rossa Italiana (PRI), 44 Grigia Alpina (GA), and 270 Pezzata Rossa d'Oropa (PRO). All animals were housed in tie-stalls and more than one breed was present at the same time on most of the farms, except on Piedmont farms, where the only breed was PRO.

Very few specific differences in housing or management were associated with different breeds. The farms studied presented many common housing and management traits, such as small herd size (32 ± 25 lactating cows/farm), mechanic manure removal (twice/day), the presence of hard flooring materials (concrete or stone), with straw bedding in most cases (except for a few cases with other natural materials, e.g., sawdust or dry fallen leaves), and an average stall length of 175 ±13 cm. Some differences among breeds existed, such as stall width: F = 108 ± 13 cm; B = 113 ± 12 cm; PRI= 106 ± 14 cm; GA = 121 ± 3 cm; PRO = 107 ± 8 cm. About half of the animals (independently of breed) were housed in stalls with presence of partitions and of mats in the lying down area. The only exceptions were PRO farms, where 94% of animals were housed without partitions and without mats. The only remarkable management difference was the possibility of access to pasture, that was given to 31% of F, 82% of B, 49% of PRI, 0% of GA and 100% of PRO. Although F and, to a lesser extent, B are widespread breeds specifically selected for milk production, the other breeds are officially regarded as dual-purpose breeds. However, during the last decades, PRI underwent a strong selective pressure, leading to a current milk yield similar to that of B, whereas GA and PRO exhibit low levels of milk production and are considered rustic breeds, well adapted to local conditions, mainly Bolzano and Trento provinces (Eastern Alps) for GA, and Biella and Vercelli provinces (Western Alps) for PRO. The PRO breed has a particularly limited spread and numerical consistency (7,800 heads in 450 farms; Lucchesi and Mattiello, 2008), yet it has a local importance for the production of typical cheese (Battaglini et al., 2000). Table 1 summarizes milk production traits deriving from national statistics (AIA, 2010), which reflect the genetic improvement for increased productivity of each considered breed.

Breed[1]	Controlled cows[2] (n)	Milk production (kg)	Fat (%)	Protein (%)
F	587,100	8,869	3.68	3.38
B	59,769	6,606	3.98	3.59
PRI	30,811	6,351	3.87	3.46
GA	5,428	4,745	3.69	3.37
PRO	1,798	1,825	3.58	3.44

Table 1 - Average lactation yield per cow by breed deriving from National Breeder Association statistics recorded in 2009 (AIA, 2010). [1]F = Italian Holstein-Friesian; B = Italian Bruna; PRI = Pezzata Rossa Italiana; GA = Grigia Alpina; PRO = Pezzata Rossa d'Oropa. [2]Registered cows belonging to all Italian farms joining the AIA.

MATERIALS AND METHODS

Animal-based indicators were used to evaluate the welfare state of individual cows. Most of the variables recorded derived from the protocol set up in the EU Welfare Quality® project (Welfare Quality®, 2009) and they included the presence of integument alterations (hairless patch areas, lesion/swollen areas, or overgrown claws) and lameness. Additionally, we observed shoulder conformation to detect the presence of a physical malformation defined as "open" shoulders (Mattiello, 2008). For this last variable, in the data set we included data collected in a previous survey carried out on 222 cows in 18 farms in Lombardy; therefore, the total sample size for this variable was 834 (63 F, 225 B, 64 PRI, 39 GA, and 270 PRO). Data were recorded at the end of the indoor period (winter) to minimize the effect of the use of pasture on the considered variables. For integument alterations, one random side of the cow was scanned from the rear to the front, from a distance not exceeding 2 m. The following alterations (with a diameter >5 cm) were recorded: hairless patch areas (areas with hair loss or extensively thinned hair, skin not damaged, including hyperkeratosis); skin lesions (areas with damaged skin either in form of a scab or a wound) or swollen areas; overgrown claws. Claws were considered normal if they had a plain supporting surface area, if they were not bent, if 2 claws of one leg had the same length, if interdigital space was scarce or apparently null (not visible), and if the angle with the ground was between 45° and 50°. When 2 or more of these criteria were not respected, the claw was classified as overgrown. Reliability of integument alteration indicators (hairless patch areas, skin lesions/swollen areas, and overgrown claws) had been checked previously by Danuser and Regula (2001) and Zurbrigg et al. (2005), who reported an agreement from 75 to 80%. As releasing cows individually from stalls to assess locomotion is not feasible because of time constraints, staff availability, building design, and cows not accustomed to freedom, a validated stall lameness score was adopted for lameness evaluation (Leach et al., 2009a). This "standing scoring" system gives acceptable repeatability (70% agreement within and 89% between observers; Leach et al., 2009b). In this test, the cow's legs were observed while the cow was standing in her stall: the observer stood behind the animal and encouraged her to move from side to side, applying hand pressure to the hind quarters if necessary. The following indicators were recorded: the feet were rotated outwards or inwards, the cow was resting on one foot more than on the others, the cow was standing avoiding to bear weight on one foot or on part of one foot, the cow was stepping (continuously shifting weight from one foot to another), or the cow was reluctant to bear weight on one foot. When the cow was reluctant to bear weight on 1 foot, or when at least 2 of the other indicators were present, she was considered lame. In regards to shoulder conformation, special attention was paid to the presence of cows with open shoulders, which can be defined as a particular conformation where the point of the shoulder is oriented outward (not in line with the fore leg) and is accompanied by a closing elbow; this phenomenon seems to be due to a relaxation of the overscapular muscle and to reduced tonicity of the muscles of the scapular region (Mattiello, 2008). Although no scientific evidence of pain or distress in animals with open shoulders is available to date, it represents an evident physical malformation that occurs almost exclusively in tethered cows (Mattiello et al., 2009; Battini et al., 2010).

RESULTS AND DISCUSSION

All data were collected by technicians who previously received the same training. The frequency of animals with presence of hairless patch areas, lesion/swollen areas, overgrown claws, lameness, and open shoulders between each pair of breeds was compared by chi-squared test. For F, B, and PRI, within-breed comparisons were performed by chi-squared test, depending on the possibility of use of pasture. In general, the prevalence of these welfare indicators showed a decreasing trend from the more productive to the less productive breeds (Table 2).

	Breed[1]				
Indicator (% of animals)	F	B	PRI	GA	PRO
Hairless patch areas	40.4[a]	20.8[b]	21.5[b]	2.3[c]	3.3[c]
Lesion/swelling areas	34.0[a]	30.4[a]	22.8[a]	6.8[b]	1.5[c]
Overgrown claws	42.6[a]	42.7[a]	31.6[ab]	20.5[b]	8.5[c]
Lameness	39.4[a]	53.2[b]	40.5[ab]	2.3[c]	1.5[d]
"Open" shoulders	40.6[a]	29.2[b]	33.3[ab]	11.4[c]	0.4[d]

Table 2 - Prevalence of welfare problems in 5 dairy cattle breeds housed in tie-stalls in traditional alpine husbandry systems. [a–d] Values within a row with different superscript are significantly different ($P \leq 0.05$). [1]F = Italian Holstein-Friesian; B = Italian Bruna; PRI = Pezzata Rossa Italiana; GA = Grigia Alpina; PRO = Pezzata Rossa d'Oropa.

The local breeds (GA and PRO) presented a significantly lower prevalence of all the considered variables compared with the other more productive and selected breeds ($P < 0.001$ in all comparisons, except for overgrown claws, which did not differ between PRI and GA). In F, the frequency of open shoulders, hairless patch areas, and lesions/swellings was higher than in the other breeds, but these values significantly differed from those of B and PRI only for hairless patch areas ($P < 0.01$ in both cases) and from B only for open shoulders ($P < 0.05$). No differences were found for any of the considered variables between PRI and B, in agreement with previous findings by Corazzin et al. (2009). In regards to this, it should be noted that the milk production level of these 2 breeds is similar (Table 1): lower than F, but dramatically higher than GA and PRO. It is also worth noting that the prevalence of lameness is below the suggested threshold (10%; EFSA, 2009b) only for GA and PRO, whereas it is much higher in all the other breeds (Table 2). It is acknowledged that lameness and claw health may vary in response to different housing and management conditions, and especially depending on access to pasture (Loberg et al., 2004; Bielfeldt et al., 2005; Corazzin et al., 2010). Within each of the considered breeds, the use of pasture had only a limited (and sometimes contradictory) effect on the prevalence of lameness (Table 3). In fact, although an expected positive effect of pasture on lameness and claw health was recorded in F, this effect was not significant in B and an opposite effect was found on claw health in PRI. These limited differences are possibly due to the fact that data were collected at the end of the winter and therefore the effect of summer grazing was no longer apparent, as demonstrated by Corazzin et al. (2010) and Battini et al. (2010). Both GA and PRO had a lower prevalence of lameness and overgrown claws, in spite of the fact that GA never made use of pasture, whereas PRO always did. These considerations, together with the common housing and management conditions on all the considered farms, suggest that the different prevalence of these problems may be related to a breed effect. For open shoulders, the much lower value recorded in PRO compared with all other breeds ($P < 0.001$ in all comparisons) was due to the presence of only one animal showing this characteristic, and it is interesting to note that this animal was 19 yr old (an age almost impossible to find among Holstein cows).

		Breed[1]		
Indicator (% of animals)	Use of pasture	F	B	PRI
Lameness	Yes	18.2[a]	57.6	56.0
	No	47.8[b]	51.7	36.6
Overgrown claws	Yes	18.2[a]	38.5	52.0[a]
	No	52.2[b]	55.2	26.8[b]

Table 3 - Prevalence of lameness and overgrown claws depending on access to pasture for Italian Holstein-Friesian, Italian Bruna, and Pezzata Rossa Italiana. [a,b] For each indicator, values within a column with different superscripts are significantly different ($P \leq 0.05$). [1] F = Italian Holstein-Friesian; B = Italian Bruna; PRI = Pezzata Rossa Italiana. As Grigia Alpina never had access to pasture and Pezzata Rossa d'Oropa always had access to pasture, these breeds were not included in the analysis.

Dairy cows have long been selected for increased productivity, which may alter animal fitness causing problems such as increased lameness, skin vulnerability, mastitis, and infertility in high-producing dairy cows (Rauw et al., 1998; Fisher and Webster, 2009). Traits other than milk yield have also been included in selection goals. Body size, together with other type traits, has played a role in altering the appearance of highproducing cows (Hansen, 2000), leading selected breeds to higher space requirements. This might be one of the reasons why F, B, and PRI housed on mountain farms(which are often old and designed for smaller animals; Mattiello et al., 2005) present a higher frequency of hairless patch areas and of swellings and skin lesions compared with less selected breeds, possibly in response to an increased frequency of collisions with the housing structures. Furthermore, Shanks et al. (1978) reported more cases of skin or skeletal disorders in cows with high genetic potential for milk production, and this might also be related to the higher prevalence of lesions in the more productive breeds. No difference within breed was found for hairless patch areas, lesion/swollen areas, or open shoulders in response to the possibility of access to pasture.

CONCLUSIONS

Given that most of the housing and management characteristics of the 5 breeds were similar, and that access to pasture had only limited and sometimes contradictory effects on the considered welfare indicators, our results suggest that the effect of the breed significantly affected the presence of health problems and physical malformations in dairy cows housed in tie-stalls in alpine traditional husbandry systems. To improve welfare levels of dairy cattle, an urgent need exists to include traits ensuring or enhancing animal welfare in breeding programs (EFSA, 2009a,b; Fisher and Webster, 2009) and to prevent the loss of biological and genetic diversity of local breeds, which have the capacity to adapt to specific environmental conditions (Sandøe et al., 1999). According to our results, the effect of cattle breed (highly selected *vs* local breeds) should be taken into account when risk assessment for dairy cattle welfare is carried out (Mueller-Graf et al., 2008), as identifying the target populations might be a critical point in traditional alpine husbandry systems.

ACKNOWLEDGMENTS - The authors thank all the people who were involved in the collection of field data [Alessandro Bettini (Sondrio, Italy), Christine Klotz (Versuchzentrum Laimburg, Bozen, Italy), and Vittorio Lucchesi (A.S.L. BI, Biella, Italy] and all the farmers who collaborated with this survey, devoting some of their precious time to the development of the research in order to improve animal welfare. Special thanks also to Elisabetta Canali, Michela Minero, Valentina Ferrante, and Daniela Baroli (all from Università degli Studi di Milano, Dipartimento di Scienze Animali) for sharing their knowledge acquired in the Welfare Quality project that made possible the training of the observers. Finally, we acknowledge the two anonymous reviewers for their precious comments that stimulated us to perform further analysis, helping to strengthen our conclusions. Preliminary results of this research were presented at the congress "Coltivare la biodiversità. Agricoltura, foreste e territorio: conservare, innovare, pianificare," held in Milan (Italy) June 10–11 2010.

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Chapter 3

ANIMAL-BASED INDICATORS FOR ON-FARM WELFARE ASSESSMENT ON GOATS: A REVIEW*

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To be submitted

**Preliminary results have been already presented: Battini M., Vieira A., Ajuda I., Grosso L. Mattiello S., Stilwell G. Identifying promising animal-based welfare indicators in intensively bred dairy goats. Proceedings of XI International Conference on Goats, 23-27 September 2012, Las Palmas di Gran Canaria (Spain).*

ABSTRACT – This paper deals with animal-based welfare indicators with the aim of developing a valid, reliable and feasible on-farm welfare assessment protocol for goats. Among the indicators used so far in the existing literature, only practical indicators will be discussed in this review, excluding those requiring the use of specific instruments, laboratory analysis or video-recording. Only animal-based indicators were considered. The paper is divided into sections, covering four welfare principles, subdivided into twelve welfare criteria. Body condition score and displacements seem the most promising indicators to be applied for the assessment of “good feeding”; indicators related to “good housing” consider different aspects related the housing structures, such as comfort around resting (e.g. resting in contact with wall, cleanliness) or thermal comfort (e.g. panting score for the detection of heat stress, but no indicators were found to detect cold stress); as expected, many indicators were found to be related to “good health”, such as lameness, discharges, struggle behaviour during handling procedures; as to “appropriate behaviour”, displacements are important also during social interactions, but the human-animal relationship should be taken into account in farmed species welfare assessment too. This review highlights aspects of goats’ welfare that have been largely investigated, but also shows some lacks in the scientific research in this field. Adult dairy goats are the most considered category in the available literature, as they represent the main category bred in Europe. Most of the studies discussed were performed in experimental farms, so the feasibility in commercial situation of the indicators adopted in these studies needs to be carefully evaluated. Inter-observer reliability is a weak item, as it has rarely been assessed. The indicators found and discussed may be a valuable starting point to the development of an on-farm welfare assessment protocol for goats.

Keywords: animal-based indicators, welfare assessment, goats, on-farm protocol

INTRODUCTION

The market demand from the consumers for assurance schemes of high quality animal products (in terms of health, safety and respect for animal welfare) has been increasing in the last decades. In response to this demand, the assessment of animal welfare at farm level is presently an outstanding issue in the field of animal husbandry. This topic has been widely discussed at an international level, and species-specific protocols for on-farm welfare assessment are presently a major issue for the EU agricultural policy (Blokhuis et al., 2003; Sørensen and Sandøe, 2001; Webster and Main, 2003).

Welfare assessment is a multidimensional approach (Mason and Mendl, 1993), corresponding to a multicriteria evaluation issue, and it should be directed at determining the actual welfare of the animal, including both physical and mental state (EFSA Panel, 2012). Different measures can be considered: all of them are important and they do not compensate each other (Blokhuis et al., 2010). A set of criteria and animal-based indicators are likely the most appropriate scheme to assess the welfare of a target population in a valid and robust way. In 2008, the EU Welfare Quality® project defined four welfare principles, linked to twelve criteria (Blokhuis et al., 2010; Rushen et al., 2011), starting from the concept of five animals' freedoms (Brambell Committee, 1965; Farm Animal Welfare Council, 1992). The four principles identified are good feeding, good housing, good health and appropriate behaviour; each principle is phrased to communicate a key welfare question and divided in different criteria. Each welfare criterion represents a specific area of welfare, which indicates an area of concern; consequently, criteria are independent of each other and form a minimal but exhaustive list (Table 1; Welfare Quality® Protocol, 2009a).

Welfare principles	**Welfare criteria**
Good feeding	1-Absence of prolonged hunger 2-Absence of prolonged thirst
Good housing	3-Comfort around resting 4-Thermal comfort 5-Ease of movement
Good health	6-Absence of injuries 7-Absence of disease 8-Absence of pain induced by management procedures
Appropriate behaviour	9-Expression of social behaviours 10-Expression of other behaviours 11-Good human-animal relationship 12-Positive emotional state

Table 1 - Principles and criteria used for classifying the animal-based indicators (Welfare Quality® Protocol, 2009a).

Two broad categories of indicators can be used to assess animal welfare at farm level: animal-based welfare measures and resource-based factors (Main et al., 2003). The need to focus on animal-based rather than on resource-based indicators clearly emerged from the EU Welfare Quality® project; however, according to Johnsen et al. (2001), few available indicators are centred directly on the animals, and they rarely target small ruminants (Blokhuis et al., 2005). Resource-based indicators have been frequently preferred in welfare assessment protocols, because their measurement is usually quick, easy and reliable (Winckler, 2006). Nevertheless, good management and environmental resources do not necessarily result in a high standard of welfare (Winckler, 2006). This point is a considerable change in perspective from systems that mainly measured environmental aspects towards those that measure the way in which the animal itself responds to such environment (EFSA Panel, 2012). This approach seems more appropriate for measuring the actual welfare state of the animals. In fact, different individuals or different breeds can respond in different ways to the same environment. This is the case, for example, of dairy cattle in tie-stalls: Mattiello et al. (2011; see Chapter 2) pointed out that the effect of the breed significantly affects the presence of health problems and physical malformations in dairy cows in tie-stalls under the same husbandry conditions. This supports the choice of focusing mainly on animal-based indicators rather than exclusively on resource-based ones.

The aim of this paper is to review promising animal-based indicators that could be used for setting up a valid, reliable, feasible and practical on-farm welfare assessment protocol for goats.

METHODOLOGY

A review of scientific literature to date was the starting point for identifying promising indicators. Databases (Web of Science, CAB Abstracts, PubMed and Scopus) were searched for English language studies addressing goat animal-based welfare indicators since 1990. Keywords like "welfare", "measure", "indicator", "assessment", "disease", "pain", "human-animal relationship", "body condition", "lameness" were used as major descriptors combined with "goat" and "small ruminant". Many animal-based measures are simple and easy to use even under commercial conditions, but in some cases they may require further analysis in a laboratory, e.g. metabolic profiling, or may be time-consuming to collect, e.g. changes in diurnal rhythm. As our aim is to identify animal-based indicators for practical welfare assessment on-farm, we did not include any indicator that requires subsequent laboratory analysis or that exclusively concentrates on resource-based indicators, and we also excluded indicators to be collected at the slaughter house.

All the indicators used in the collected studies were classified according to the four principles and twelve criteria of Welfare Quality® assessment protocols (2009a, 2009b) (Table 1). These indicators are summarized in tables, including information on animal category, housing, sample size, and their validity, reliability and on-farm feasibility. These last attributes for each potential indicator were previously discussed and agreed by a group of experts of goats' welfare during a meeting of the European AWIN (Animal Welfare Indicators) project, held in Milan (Italy) in November 2011.

The definition of the terms used in this review is given below.

Validity: refers to the relation between a variable and what it is supposed to measure or predict (Lehner, 1998; Martin and Bateson, 2007). Criterion-related validity picks one or more criteria or standards for evaluating a scale, such as a predictive or a concurrent measure (Acock, 2008), leading to the following definitions:

- Predictive validity refers to the ability of an indicator to predict some later criterion.
- Concurrent validity stipulates that an indicator should show substantial correlation with other measures to which it is theoretically related (Frick et al., 2009)

Reliability: concerns the extent to which a measurement is repeatable and consistent (Martin and Bateson, 2007). Two main aspects are considered:

- Intra-observer reliability: agreement between observations on the same individual or group by a single observer, on at least two different occasions. The amount of time allowed between measures is critical: it can be divided into short- (one day or one week), medium- (one month), long-term reliability (one year).
- Inter-observer reliability: agreement between different observers during a simultaneous observation.

On-farm feasibility: it refers to the practical possibility of using the indicators during on-farm inspection. It takes into account time constraints, costs, possibility to perform on commercial farms, stakeholders' and farmers' acceptability (Knierim and Winckler, 2009). This kind of approach excludes some forms of measures, such as blood collection, observations performed by video-recording or the use of specific instruments (e.g. stethoscope, thermometer, heart rate monitor) (Mononen et al., 2012).

As reported above, the discussion on goat animal-based indicators will be presented following the Welfare Quality® four welfare principles and twelve criteria. Promising indicators are summarized in tables and further explained and discussed.

1. Good feeding

This welfare principle considers criteria related to “freedom from hunger or thirst” by ready access to diet and fresh water so as to maintain full health and vigour. The possible indicators for these criteria are presented in Table 2.

Animal-based welfare indicator		Age class [a]	Sex [b]	Attitude [c]	Housing system [d]	Sample size	Validity [e]	Intra-observer reliability [e]	Inter-observer reliability [e]	On-farm feasibility [e]	References
Absence of prolonged hunger	Body condition score	A	F	D	C	93	O	-	-	v	Anzuino et al., 2010
		J	M	.	E	60	v	L	-	v	McGregor and Butler, 2008
	Hair condition	A	F	D	E	48	-	-	-	v	Battini et al., 2012
	Anal soiling dirtiness	A	F	D	C	1520	-	-	-	v	Anzuino et al., 2010
	Feeding simultaneously	A/J	F	D	E	96	v	M	-	x	Aschwanden et al., 2009a
	Duration of the first simultaneous feeding bout	A/J	F	D	E	96	v	M	-	x	Aschwanden et al., 2009a
	Rate of agonistic interactions	A/J	F	D	E	96	v	M	-	x	Aschwanden et al., 2009a
	Rate of displacements received whilst feeding	A/J	F	D	E	70	v	L	-	x	Aschwanden et al., 2009b
	Rate of agonistic interactions initiated whilst feeding	A/J	F	D	E	70	x	L	-	x	Aschwanden et al., 2009b
	Frequency of fighting	K	F/M	.	E	30	v	M	-	x	Van et al., 2007
	Displacement at feed barrier	A	F	D	E	48	v	S	-	v	Jørgensen et al., 2007
		K	F/M	.	E	30	v	M	-	v	Van et al., 2007
	Butt at the feeding time	A	F	D	E	48	v	S	-	v	Jørgensen et al., 2007
	Withdrawal at the feeding time	A	F	D	E	48	x	S	-	v	Jørgensen et al., 2007
	Push at the feeding time	K	F/M	.	E	30	v	M	-	v	Van et al., 2007
	Threat at the feeding time	K	F/M	.	E	30	v	M	-	v	Van et al., 2007
	Head thrusts at the feeding time	K	F/M	.	E	30	v	M	-	v	Van et al., 2007
	Length of feeding bouts interrupted due to a social reason	A/J	F	D	E	70	v	L	-	x	Aschwanden et al., 2009b
	Number of times supplanted at the feeding place	K	.	.	E	13	-	-	-	x	Mazurek et al., 2005
	Eating	A	F	D	E	48	v	S	-	x	Jørgensen et al., 2007
	Latency to first feeding-place change	A/J	F	D	E	96	v	M	-	x	Aschwanden et al., 2009a
	Rate of feeding-place changes	A/J	F	D	E	96	v	M	-	x	Aschwanden et al., 2009a
	Total feeding time	A/J	F	D	E	70	x	L	-	x	Aschwanden et al., 2009b
	Number of times spent at the feeding place	K	.	.	E	13	-	-	-	x	Mazurek et al., 2005
	Total duration of feeding at night	A/J	F	D	E	70	x	L	-	x	Aschwanden et al., 2009b
	Queuing at the feeding rack	A	F	D	E	48	v	S	-	x	Jørgensen et al., 2007

	Standing/walking	A	F	D	E	48	x	S	-	x	Jørgensen et al., 2007
	Lying	A	F	D	E	48	v	S	-	x	Jørgensen et al., 2007
	Total time spent suckling	K	.	.	E	13	-	-	-	x	Mazurek et al., 2005
Absence of prolonged thirst	Displacements from the nipple drinker	A	F	D	E	30	v	S	-	v	Ehrlenbruch et al., 2010a
	Total drinking time	A	F	D	E	30	v	S	-	x	Ehrlenbruch et al., 2010a
	Drinking frequency	A	F	D	E	30	v	S	-	x	Ehrlenbruch et al., 2010a
	Time per drinking bout	A	F	D	E	30	v	S	-	x	Ehrlenbruch et al., 2010a
	Time spent drinking	A	F	D	E	30	x	S	-	x	Ehrlenbruch et al., 2010a
	Time spent queuing at the drinker	A	F	D	E	30	v	S	-	x	Ehrlenbruch et al., 2010a
	Drinking duration	A	F/M	.	E	14	x	S,L	-	x	Ogebe et al., 1996
	Drinking frequency	A	F/M	.	E	14	x	S,L	-	x	Ogebe et al., 1996

Table 2 – Animal-based indicators for assessing “good feeding”, excluding physiological measurements. [a] Age class: “A” Adult (>6 months), “J” Juvenile (3-6 months), “K” Kid (<3 months). [b] Sex: “M” Male, “F” Female. [c] Attitude: “D” Dairy, “Me” Meat, “F” Fiber. [d] Housing system: “C” Commercial farm, “E” Experimental farm. [e] Validity, reliability, feasibility: “v” tested and valid or reliable or feasible, “x” tested and not valid, not reliable or not feasible, “-” not tested, “O” validity assessed in other species; “S” short-term reliability, “M” mid-term reliability, “L” long-term reliability.

i) absence of prolonged hunger

Goats’ nutritional status , as well as in other species, is often assessed by body condition score (BCS), that is considered a valid indicator in many species (De Rosa et al., 2009; Welfare Quality® Protocol, 2009a; Welfare Quality® Protocol, 2009b). A wide range of BCS systems has been developed and used for research purposes and practical monitoring on commercial farms. The main distinctions between systems are whether they are merely visual or require palpation, and whether the animal is assessed as a whole, or separate scores are given for different anatomical regions, which are then summarized or adjusted to give a whole animal score (Welfare Quality® Protocol, 2009a). Assessing BCS in goats could be quite hard without a specific training and previous experience, because these animals generally have visceral and internal fat deposits rather than subcutaneous fat (McGregor and Butler, 2008). McGregor and Butler (2008) applied a BCS on the basis of 1-5 point scale identical to that described by Jefferies (1961) for sheep. However, the purpose of including BCS in on-farm welfare assessment schemes is to identify animals that are either too thin or too fat, hence the scoring system does not need to be particularly detailed. For example, in the welfare protocols for cattle set up by Welfare Quality® Protocol (2009a), only 3 BCS levels have been adopted. In this view, Anzuino et al. (2010) divided goats into obviously thin and obviously fat animals. Until now, BCS on goats has been assessed only by palpation, because this seems the more reliable method, but this method is time consuming, and it requires restraining the animals, possibly associated to stress. Therefore, the on-farm feasibility of a BCS based on palpation is low, and the development of a visual method to highlight animals in extreme nutritional conditions (i.e. too thin or too fat) is desirable.

Behaviour and social interactions during feeding time can be good indicators to evaluate the absence of prolonged hunger. Feed can be a limited resource either because the amount of feed is restricted or because feeding space is not accessible for all individuals in the group (Jørgensen et al., 2007). Feed intake of goats can be altered by the unavailability of space (Jørgensen et al., 2007), but the use of this parameter as indicator was considered not feasible for our purposes. Queuing animals at the feeding rack may be a promising indicator to collect on-farm (Jørgensen et al., 2007; Fig. 1), but the use of 24h video-recording is not applicable to our purposes (Jørgensen et al., 2007), hence different strategies to collect this indicator need to be explored (e.g. direct data collection per segment/pen in a determined time).

Fig. 1 – Animals queuing at the feeding rack

Among different aggressive behaviours, displacements seem the best indicator according to Aschwanden et al. (2009b) and Jørgensen et al. (2007). This indicator also proved to be valid to assess absence of prolonged hunger in kids (Van et al., 2007). The validity of these indicators has been assessed, as pointed out by other authors in other species, such as pigs and cattle (Nielsen et al., 1995; Olofsson, 1999; Shinde et al., 2004). However, an important issue needs to be considered: goats are not well synchronized in their feeding behaviour, especially in a competitive environment with reduced space in order to optimize their access to feed, as animals may consume the feed at different times of the day (Olofsson, 1999; Shinde et al., 2004). This feeding strategy should be considered, as it might lead to unpredictable results when using agonistic interactions as indicator of good feeding.

Some authors suggest that hair condition can be used as a first warning about goats' health and nutritional status (Lengarite et al., 2012; Pritchard and Whay, 2003; Sarkar et al., 2010; Smith and Sherman, 2009; Veit et al., 1993); this concept finds a large consensus among farmers. Preliminary researches seem to confirm that this indicator can be valid and practical for on-farm welfare assessment, as goats with rough or scurfy hair were easy to detect (Battini et al., 2012; see Chapter 5).

Dirty anal soiling is another interesting indicator of good feeding, as it reflects problems with nutrition and digestion (Grove-White, 2004). The validity of this indicator has been never assessed in goats, but it is already accepted and used in cattle (Welfare Quality® Protocol, 2009a). It has been considered a feasible indicator to use on-farm (Anzuino et al., 2010); however, it is difficult to assess it in the pen, and the best location to record it seems to be the milking parlour.

ii) absence of prolonged thirst

Evaluating the lack of water using animal-based indicators could be quite hard, and scarce literature sources are available on this topic.

Goats mainly drink during feeding (Rossi and Scharrer, 1992) and this behaviour is generally socially facilitated (Forkman, 1996) and synchronized (Rook and Penning, 1991). Reduced possibility to simultaneous drinking can lead to decreased drinking time and hence lower the water intake (Ogebe et al., 1996; Van et al., 2007). Queuing animals and displacements at the drinkers may be used to detect animals suffering thirst, as Ehrlenbruch et al. (2010a) found increasing agonistic behaviour and queuing when more than 15 goats have to drink from the same nipple. These indicators have been collected by 2h video-recording. As already stated for queuing animals and displacements during feeding time, the use of cameras is not feasible for practical on-farm use; therefore, these indicators may be included into a protocol only if a method for reliable and effective direct observations on representative samples is developed.

2. Good housing

This welfare principle involves criteria related to structures and housing conditions in the farm. The possible animal-based indicators for these criteria are presented in Table 3.

Animal-based welfare indicator		Age class [a]	Sex [b]	Attitude [c]	Housing system [d]	Sample size	Validity [e]	Intra-observer reliability [e]	Inter-observer reliability [e]	On-farm feasibility [e]	References
Comfort around resting	Resting in contact with wall	A	F	D	E	24	v	S	-	v	Andersen and Bøe, 2007
		A	F	D	E	24	v	S	-	v	Ehrlenbruch et al., 2010b
		A	F	D	C	40	x	M	-	v	Loretz et al., 2004
	Resting in contact with other goats	A	F	D	E	24	x	S	-	x	Andersen and Bøe, 2007
		A	F	D	C	40	x	M	-	x	Loretz et al., 2004
		A	F	D	E	24	x	S	-	x	Ehrlenbruch et al., 2010b
	Resting synchronously	A	F	D	E	24	x	S	-	x	Andersen and Bøe, 2007
	Resting in the activity area	A	F	D	E	24	x	S	-	x	Andersen and Bøe, 2007
	Time spent lying	A/J	F	D	E	70	x	L	-	x	Aschwanden et al., 2009b
		A	F	D	C	40	v	M	-	x	Loretz et al., 2004
	Average distance between animals while lying	A	F	D	C	40	x	M	-	x	Loretz et al., 2004
	Standing	A	F	D	E	24	x	S	-	x	Andersen and Bøe, 2007
	Moving	A	F	D	E	24	x	S	-	x	Andersen and Bøe, 2007
	Nosing on/exploring another goat	A	F	D	E	24	x	S	-	x	Andersen and Bøe, 2007
	Frontal clash	A	F	D	E	24	x	S	-	x	Andersen and Bøe, 2007
	Butt	A	F	D	E	24	x	S	-	x	Andersen and Bøe, 2007
		A	F	D	E	24	x	S	-	x	Ehrlenbruch et al., 2010b
	Chase	A	F	D	E	24	x	S	-	x	Andersen and Bøe, 2007
		A	F	D	E	24	x	S	-	x	Ehrlenbruch et al., 2010b
	Threat	A	F	D	E	24	x	S	-	x	Andersen and Bøe, 2007
	Push	A	F	D	E	24	x	S	-	x	Ehrlenbruch et al., 2010b
	Avoidance	A	F	D	E	24	x	S	-	x	Andersen and Bøe, 2007
	Withdrawal	A	F	D	E	24	x	S	-	x	Andersen and Bøe, 2007
		A	F	D	E	24	x	S	-	x	Ehrlenbruch et al., 2010b
	Displacements	A	F	D	E	24	v	S	-	x	Andersen and Bøe, 2007
		A	F	D	C	40	x	M	-	x	Loretz et al., 2004
		A	F	D	E	24	x	S	-	x	Ehrlenbruch et al., 2010b
	Cleanliness	A	F	D	C	1520	O	-	-	v	Anzuino et al., 2010
Thermal comfort	Lying	A	F	D	E	9	v	L	-	x	Bøe et al., 2007
	Standing	A	F	D	E	9	x	L	-	x	Bøe et al., 2007
	Moving	A	F	D	E	9	v	L	-	x	Bøe et al., 2007
	Eating	A	F	D	E	9	v	L	-	x	Bøe et al., 2007
		A	F	D	E	30	v	S	-	x	Darcan et al., 2007a
		A	F	D	E	30	v	S	-	x	Darcan et al., 2007b
	Ruminating	A	F	D	E	30	v	S	-	x	Darcan et al., 2007a
		A	F	D	E	30	v	S	-	x	Darcan et al., 2007b
	Drinking	A	F	D	E	30	v	S	-	x	Darcan et al., 2007a
		A	F	D	E	30	v	S	-	x	Darcan et al., 2007b
	Walking	A	F	D	E	30	v	S	-	x	Darcan et al., 2007a
		A	F	D	E	30	v	S	-	x	Darcan et al., 2007b
	Resting	A	F	D	E	30	v	S	-	x	Darcan et al., 2007a
		A	F	D	E	30	v	S	-	x	Darcan et al., 2007b
	Panting score	A	F	D	E	30	v	S	-	v	Darcan et al., 2007a
		A	F	D	E	30	v	S	-	v	Darcan et al., 2007b
	Drinking duration	A	F/M	.	E	14	x	S,L	-	x	Ogebe et al., 1996
	Drinking frequency	A	F/M	.	E	14	x	S,L	-	x	Ogebe et al., 1996
	Duration of feed consumption	A	F/M	.	E	14	v	S,L	-	x	Ogebe et al., 1996
Ease of movement	Kneeling	A	F	D	C	11403	v	-	-	v	Anzuino et al., 2010
	Standing up score	A	F	D	E	35	v	-	-	v	Mazurek et al., 2007
	Duration of leaving the feed barrier	A	F	D	E	55	v	M	-	x	Nordmann et al., 2011

Table 3 – Animal-based indicators for assessing “good housing”, excluding physiological measurements. [a] Age class: “A” Adult (>6 months), “J” Juvenile (3-6 months), “K” Kid (<3 months). [b] Sex: “M” Male, “F” Female. [c] Attitude: “D” Dairy, “Me” Meat, “F” Fiber. [d] Housing system: “C” Commercial farm, “E” Experimental farm. [e] Validity, reliability, feasibility: “v” tested and valid or reliable or feasible, “x” tested and not valid, not reliable or not feasible, “-” not tested, “O” validity assessed in other species; “S” short-term reliability, “M” mid-term reliability, “L” long-term reliability.

i) comfort around resting

As defined in Welfare Quality® Protocol (2009a), “animals should have comfort when they are resting”.

Many studies state that goats, as well as other farm animals, have a preference to rest against a wall (goats: Andersen and Bøe, 2007; Ehrlenbruch et al., 2010b; cattle: Stricklin et al., 1979; sheep: Bøe et al., 2006; Færevik et al., 2005; Marsden and Wood-Gush, 1986; fowl: Cornetto and Estevez, 2001). This may be due to increased comfort or to an anti-predator strategy suggesting that the animals may feel safer close to a wall than in an open area. If space allowance is reduced, goats are forced to choose different areas, including those without walls, to lie down. Resting in contact with the wall showed a predictive validity in Andersen and Boe (2007) and Ehrlenbruch et al. (2010b) in a lying size area ranging from 0.5 to 1.0 m^2/goat, but not in Loretz et al. (2004) in a lying area from 1.0 to 2.0 m^2/goat. This finding supports the hypothesis of using this indicator to detect comfort around resting. Feasibility for our purposes needs to be improved, as data collection in the cited researches was only performed by video-recording, during many hours or days, resulting too time consuming. Direct observations need to be applied. Moreover, the right moment to observe animals is crucial. Generally, animals tend to have synchronized resting and activity patterns (Rook and Penning, 1991). Synchrony during resting time varies between studies (41.7% in Ehrlenbruch et al., 2010b; 8.5% and 21.1% in Andersen and Bøe, 2007, increasing according to the size of the lying size area). In addition, goats rest in the less comfortable activity area when space decreases (Andersen and Bøe, 2007). All these considerations about resting patterns suggest that this indicator can be approached trying to identify a proportion between animals resting in contact with the wall or not, during the lying period.

Goats dislike wet areas when resting. Cleanliness is already used as a valid welfare indicator in pigs, poultry and cattle (Hughes, 2001; Scott et al., 2007; Whay et al., 2003). Dairy goats are much cleaner than dairy cattle because they generally have much drier faecal matter and usually have a cleaner environment, being housed on straw bedding all year round. Manure management is much easier in goats than in cattle, but the way in which goats are moved and handled to the milking parlour, as well as the cleanliness and dryness of walkways, may significantly influence the goats’ cleanliness. In fact, the main factors affecting the cleanliness of dairy cattle limbs have been reported to be the frequency of barn alleyways' cleaning of, the ease in moving procedures of cattle, the group density and the number of times animals are moved (Hughes, 2001; Schreiner and Ruegg, 2003). Anzuino et al. (2010) considered cleanliness as a possible welfare indicator, scoring some areas from dirty to very dirty. This indicator is probably feasible; however, the best location to score it has to be identified. Preliminary researches suggest that the milking parlour can be a good location to record cleanliness on the rear area (Vieira et al., 2012), but a sample strategy needs to be improved in order to get information about the front area, such as the sternum region over which goats lie.

ii) thermal comfort

It is known that ruminants have wide comfort zones and a high degree of thermal tolerance, with exception for the extremes of the scale of temperature that may affect their welfare and thus productivity (Sejian and Srivastava, 2010). Goats mainly suffer from inadequate temperature, high humidity and rain (McGregor, 2002). Signs of physiological and heat stress are shown as the air temperature falls below 15°C and, under wet and windy conditions. Thermal comfort is not very well documented in literature, meaning that "animals should neither be too hot nor too cold" (Welfare Quality® Protocol, 2009a).

Breath rate measurement can provide reliable and practical information for estimating the severity of heat stress in farm animals (Silanikove, 2000). A panting score has already been used for cattle (Gaughan et al., 2003) and it also showed a predictive validity and on-farm feasibility in goats (Darcan et al., 2007a, 2007b). It is assigned on the basis of visual observation of behaviour, using a 5 point scale, but probably a simplified score system could be considered to improve the feasibility and highlight serious and extreme heat stress situations.

No feasible indicator has been found to evaluate thermal stress in low temperature conditions, hence studies are required to gather information about cold stress. Some specific behaviour and posture likely related to cold stress have been found during preliminary observations in farms, such as shivering or bristling hair on the back, but no reliable information are available at the moment.

Some physiological and blood parameters have been identified as valid indicators, such as water intake, rumination rate, rectal temperature, pulse and respiration rate (Ogebe et al., 1996; Darcan et al., 2007a, 2007b), skin temperature (Darcan et al., 2007a, 2007b) and glucose, total protein, total cholesterol, urea, cortisol and aldosterone (Sejian and Srivastava, 2010). For on-farm welfare assessment, the use of these indicators is not feasible, but they can be very useful for validating more practical indicators.

iii) ease of movement

By ease of movement we mean the freedom of the animals to explore their surroundings without injuring themselves or, in other words, "animals should have enough space to be able to move around freely" (Welfare Quality® Protocol, 2009a). In order to assure this, the housing conditions should allow animals to move freely without risk of injury, the density of the animals has to be correct and the animals have to be in sound conditions to be able to walk, lie down and stand up.

Kneeling has been considered as an important indicator by Anzuino et al. (2010). This behaviour seems to be very important, since the authors found an average prevalence of farms with kneeling goats of 87.5% (Fig. 2).

Fig. 2 – Kneeling goat

A standing up score has been used by Mazurek et al. (2007) to detect problems in transition movement, similarly to that already adopted for cattle (Welfare Quality® Protocol, 2009a), although the description of the transition movement in this paper is unclear, as the wrong movement (getting up raising the front part of the body first and subsequently the hind one) seems to be scored as the best one. A concurrent validity has been found between kneeling, standing up score and the prevalence of severely lame goats (Anzuino et al., 2010; Mazurek et al., 2007). The on-farm feasibility is higher in kneeling: a sampling strategy needs to be improved, but data collection is quite easy to perform, whereas the standing up score is strictly related to a specific moment, and requires a perfect timing to capture the transition movement from the beginning.

The duration taken by the goats to leave the feed barrier (Nordmann et al., 2011) has shown to be a valid indicator to detect problems related to the housing structure, but it is considered unfeasible in commercial farming conditions, as a huge number of animals should be directly recorded.

3. Good health

Indicators related to health are the most represented in our review, probably because there are many more studies on these issues than on other criteria. The possible indicators for these criteria are presented in Table 4.

Animal-based welfare indicator		Age class [a]	Sex [b]	Attitude [c]	Housing system [d]	Sample size	Validity [e]	Intra-observer reliability [e]	Inter-observer reliability [e]	On-farm feasibility [e]	References
Absence of injuries	Lameness	A	F	D	E	170	v	S	-	v	Christodoulopoulos, 2009
		K/J/A	F/M	.	C	100/76/308	O	-	-	v	Eze, 2002
		A	F	D	C	1520	O	-	-	v	Anzuino et al., 2010
		A	F	D	E	40	O	-	-	v	Mazurek et al., 2007
	Claw overgrowth	A	F	D	C	1520	O	-	-	v	Anzuino et al., 2010
	Standing up score	A	F	D	E	35	v	-	-	v	Mazurek et al., 2007
	Lesions and swellings	A	F	D	C	1520	O	-	-	x	Anzuino et al., 2010
	Teats and udder abnormalities	A	F	D	C	1520	O	-	-	v	Anzuino et al., 2010
	Teats and udder conformation trait	A	F	D	C	1520	O	-	-	v	Anzuino et al., 2010
Absence of disease	Discharges	A	F	D	C	1520	-	-	-	v	Anzuino et al., 2010
	Obviously sick/dull goats	A	F	D	C	11403	-	-	-	x	Anzuino et al., 2010
	Pruritus	A	F	D	C	11403	-	-	-	x	Anzuino et al., 2010
	Coughing	A	F	D	C	11403	-	-	-	x	Anzuino et al., 2010
	Dyspnoea	A	F	D	C	11403	-	-	-	x	Anzuino et al., 2010
	Hair condition	A	F	D	E	48	v	-	-	v	Battini et al., 2012
	Presence of abscesses	A	F	D	C	16	-	-	-	v	Ferrante et al., 2012
	Isolated animals	.	.	.	.	.	.	.	.	.	.
	Hesitate/refuse movement	A	F	D	E	108	v	-	-	x	Mazurek et al., 2005
		A	F	D	E	108	v	-	-	x	Mazurek et al., 2007
	Cleanliness	A	F	D	C	1520	O	-	-	v	Anzuino et al., 2010
	Body condition score	J	M	.	E	60	v	L	-	v	McGregor and Butler, 2008
		A	F	D	C	93	O	-	-	v	Anzuino et al., 2010
		A	F	D	E	60	v	S	-	v	Laporte-Broux et al., 2011
	Lying down	A	F	D	E	28	x	S	-	x	Laporte-Broux et al., 2011
	Standing immobile	A	F	D	E	28	v	S	-	x	Laporte-Broux et al., 2011
	Standing at neck-lock	A	F	D	E	28	v	S	-	x	Laporte-Broux et al., 2011
	Eating	A	F	D	E	28	v	S	-	x	Laporte-Broux et al., 2011
	Walking	A	F	D	E	28	v	S	-	x	Laporte-Broux et al., 2011
	Threat	A	F	D	E	60	x	S	-	x	Laporte-Broux et al., 2011
	Chase	A	F	D	E	60	x	S	-	x	Laporte-Broux et al., 2011
	Butt	A	F	D	E	60	x	S	-	x	Laporte-Broux et al., 2011
	Avoidance	A	F	D	E	60	x	S	-	x	Laporte-Broux et al., 2011
	Self-grooming	A	F	D	E	60	v	S	-	x	Laporte-Broux et al., 2011
	Positive interactions	A	F	D	E	60	v	S	-	x	Laporte-Broux et al., 2011
	Novel arena test	A	F	D	E	28/25/22	v	S	-	x	Laporte-Broux et al., 2011
	Novel object test	A	F	D	E	28/25/22	x	S	-	x	Laporte-Broux et al., 2011
	Ear tear	A	F	D	C	1338	-	-	-	v	Anzuino et al., 2010

	Struggles	K	M	.	C	90	v	S	v	v	Souad et al., 2011
		K	F/M	.	E	56	v	S	-	v	Alvarez et al., 2009
		K	F/M	.	E	29	v	S	v	v	Alvarez and Gutiérrez, 2010
	Vocalizations	K	M	.	C	90	v	S	v	v	Souad et al., 2011
		K	F/M	.	E	56	v	S	-	v	Alvarez et al., 2009
		K	F/M	.	E	29	v	S	v	v	Alvarez and Gutiérrez, 2010
		J	M	Me/D	E	48	-	M	-	v	Ndou et al., 2010
	Abnormal postures	K	M	.	C	90	v	S	v	x	Souad et al., 2011
	Active pain behaviour	K	M	.	C	90	v	S	v	x	Souad et al., 2011
	Eliminatory(defecation, urination) behaviour	K	M	.	C	90	v	S	v	x	Souad et al., 2011
	Feeding behaviour	K	M	.	C	90	x	S	v	x	Souad et al., 2011
	Pen scoring	J	M	Me/D	E	48	-	M	-	x	Ndou et al., 2010
	Crush score	J	M	Me/D	E	48	-	M	-	x	Ndou et al., 2010
	Flight speed	J	M	Me/D	E	48	-	M	-	x	Ndou et al., 2010
	Flight time	J	M	Me/D	E	48	-	M	-	x	Ndou et al., 2010

Table 4 – Animal-based indicators for assessing "good health", excluding physiological measurements. [a] Age class: "A" Adult (>6 months), "J" Juvenile (3-6 months), "K" Kid (<3 months). [b] Sex: "M" Male, "F" Female. [c] Attitude: "D" Dairy, "Me" Meat, "F" Fiber. [d] Housing system: "C" Commercial farm, "E" Experimental farm. [e] Validity, reliability, feasibility: "v" tested and valid or reliable or feasible, "x" tested and not valid, not reliable or not feasible, "-" not tested, "O" validity assessed in other species; "S" short-term reliability, "M" mid-term reliability, "L" long-term reliability.

i) absence of injuries

Injuries in farm animals are probably one of the most frequent issues to be evaluated during a welfare assessment. According to this principle, "animals should be free from disease, e.g. skin damage and locomotory disorders" (Welfare Quality® Protocol, 2009a).

Lameness is considered in several papers, due to its high prevalence in commercial farms (9.1% to 24%; Christodoulopoulos, 2009; Eze, 2002; Hill et al., 1997; Mazurek et al., 2007). Furthermore, it is an important behavioural indicator of pain and may lower productivity in dairy goats by reducing their milk yield (Christodoulopoulos, 2009) and fertility, and contributing to pregnancy toxaemia and neonatal diseases (Eze, 2002). There are no well-developed, established gait scoring systems for goats, so lameness is generally scored by a point scale (Anzuino et al., 2010; Mazurek et al., 2007) or lame/not lame goats (Christodoulopoulos, 2009). Animals can be scored at the exit of the milking parlour (Anzuino et al., 2010) or in the group pen (Mazurek et al., 2007; Christodoulopoulos, 2009). According to Anzuino et al. (2010), one notable finding is that the prevalence of lameness estimated while the goats are in their pens is usually much lower than that observed when the goats exit the parlour. This can be due to improved visibility when the goats are exiting the parlour or to the fact that the goats' locomotion is better when they are walking on soft straw surfaces in their pens, or that any lameness worsens when animals walk on hard surfaces. This finding is important, as it suggests that assessing lameness in goats while they are housed in their pens may underestimate the severity and the prevalence of the problem. This outcome should take into account a reliable sampling strategy, as already observed by Vieira et al. (2012), higher prevalence of lame goats can be found in last groups entering the milking parlour, compared to the first groups. Moreover, estimates of lameness made in the pens are significantly lower than the estimates from observations of individual goats (Anzuino et al., 2010). Lameness scores have been already validated in other species (e.g. for cattle: Welfare Quality® Protocol, 2009a). However, some differences between species in the scoring system can be observed: in cattle, animals that are sound can be differentiated from those that are slightly lame (Bell et al., 2009), whereas the scoring systems used until now in goats only detect animals that are obviously lame. To make the scoring system more effective, without reducing the on-farm feasibility, a possible advance may be the development of a visual assessment scale on individual goats, like the visual analogue scale (VAS) for continuous scoring recently set up for cattle (Tuyttens et al., 2009). The use of this tool would obviously require a hard training of the observer, and its reliability needs to be tested.

In addition to lameness score, in Mazurek et al. (2007) goats received a standing up score, as already widely explained in paragraph 2.iii).

Claw overgrowth is a major problem in commercial dairy goat farms (79.8% of goats observed, but lame goats have been found in 100% of farms; Anzuino et al., 2010), probably due to a lack of hoof wear when animals are housed on straw bedding and/or to poor management (Fig. 3). In British dairy goats, an inverse relationship between the frequency of foot trimming and the prevalence of lameness has been reported (Anzuino et al., 2010; Eze, 2002; Hill et al., 1997), reflecting general overall poor management in some farms. This indicator can be scored from moderate to severe overgrowth (Anzuino et al., 2010), but validity in goats has been never assessed, whereas in cattle some systems have been successfully developed (Huxley and Whay, 2007; Welfare Quality® Protocol, 2009a). The main issue is to exactly and practically define when a claw is overgrown, and when this can also lead to lameness or pain for the animals. A study reports a higher incidence of claw overgrown in posterior than in anterior claws (Ajuda et al., 2012), so an assessment in the milking parlour seems to be feasible and effective, especially if supported by an effective sampling strategy (Vieira et al., 2012).

Fig. 3 – Overgrown claws

The prevalence of location and type of lesions (including skin damages, swellings and hair losses) is another possible indicator of good health, and it may vary between farms and between goats in the same farm (Anzuino et al., 2010). Lesions on the skin of the body and the neck are quite frequent, but they mainly consist of hair loss, whereas most of lower limb skin lesions consist of both skin damage and hair loss. Such lesions may not be painful, but can still be important measures of welfare, reflecting structure deficiencies (e.g. physical obstructions to normal behaviours) or may arise from trauma (e.g. hornless goats housed with horned goats; Anzuino et al., 2010).

In dairy animals, other possible animal-based indicators are lesions and abnormalities of teats and udder (Anzuino et al., 2010). Teat and udder abnormalities have been found with a prevalence of 33.8% in British farms (Anzuino et al., 2010), and include lesions, wounds, inflammations and accessory teats. Udder and teat lesions can affect both welfare and production in dairy goats (Contreras et al., 2007; Leitner et al., 2008; Perrin et al., 1997), but there is little published information about the welfare significance and aetiology of different lesions (Menzies and Ramanoon, 2001). Certain aspects of dairy goat farming, such as rapid milking rates, large herd sizes, highly productive goats, number of stockpersons and minimal hygiene routine at milking, as well as some specific goat behaviour, such as teat biting, may contribute to the development of teat and udder lesions (Anzuino et al., 2010).

Evaluating teat and udder conformation traits may be important for goat welfare, as asymmetry (Fig. 4) and pendulous udder (Fig. 5), were recorded with a prevalence of 7.6% in British farms (Anzuino et al., 2010). Pendulous udders are commonly observed, although few goats have very pendulous udders. Some studies on dairy goats showed a relationship between pendulous udders and mastitis (Ameh et al., 1993; Deinhofer and Pernthaner, 1995), partly due to the increased risk of injury to the udder and teats when there is short distance between the teat ends and the floor. Udder asymmetry has been associated with intramammary infection (Alawa et al., 2000). Ameh et al.

(1993) and Ameh and Tari (1999) found teat injuries to be associated with mastitis. It is assumed that a chronic change does remain even after an udder has recovered from infection or injury (Klaas et al., 2004).

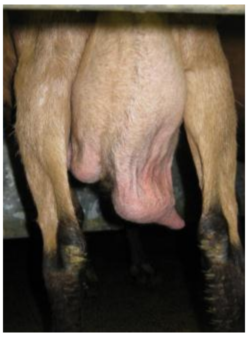

Fig. 4 – Asymmetry of the udder

Fig. 5 – Goat with pendulous udder

When udder and teat lesions, abnormalities and conformation trait are macroscopic, they can be easily recorded by visual assessment, without palpating the animals. The milking parlour seems the best location to assess these indicators, whereas a pen assessment could be more effective in assessing lesions on the whole body.

ii) absence of disease

According to Welfare Quality® Protocol (2009a), “animals should be free from disease, i.e. animal unit managers should maintain high standards of hygiene and care”.

Many indicators related to disease have been never validated in goat studies, but they have been already validated in other species (cattle, Welfare Quality® Protocol, 2009a).

BCS can be usefully adopted to prevent the occurrence of pregnancy toxaemia by monitoring the nutritional status of periparturient goats (Laporte-Broux et al., 2011). This disorder is one of the most common diseases affecting small ruminants in the last month of gestation (Lima et al., 2012). It can happen if goats in the last third of their pregnancy with multiple foetus do not have their energy needs fulfilled, because they are underfed or because they are not capable of ingesting enough dry matter. Blood parameters can be employed to confirm and validate the use of some indicators when pregnancy toxaemia occurs (Laporte-Broux et al., 2011). For our purposes, they are not considered, but blood glucose, NEFA, BHB, urea, and insulin support the use of BCS in a validation process (Laporte-Broux et al., 2011).

The presence of external abscesses is a common sign of pathology in goats. In most cases, external abscesses are located at lymph nodes areas (mainly, mandibular, prescapular, prefemoral, and supramammary lymph nodes; Smith and Sherman, 2009). This external sign is often associated to a chronic contagious disease called caseous lymphadenitis that is caused by *Corynebacterium pseutuberculosis*. This disease can also affect internal lymph nodes or organs, such as lungs, liver or kidneys, but this form cannot be observed externally and is not very common in goats (Smith and Sherman, 2009). A preliminary study (Ferrante et al., 2012) suggests that the presence of abscesses can be considered a valid and feasible animal based indicator for on-farm welfare assessment, reflecting a general poor condition of the animals, as shown by the reduced feeding time and the low BCS recorded in goats with external abscesses.

The hair condition can also be regarded as an interesting indicator to gather information not only on goats' nutritional status (see paragraph 1.i), but also on their health status. In fact, preliminary investigations showed a higher prevalence of abnormal lung sounds (probably related to chronic respiratory disease) and a general poor health condition in goats with rough and scurfy hair (Battini et al., 2012).

Goats presenting discharges have been found in small percentages by Anzuino et al., (2010), more specifically vulvar (5%, mainly haemorrhagic), nasal (0.6%) and ocular (6%) discharges. Discharges may also be considered, as these indicators have already been used in cattle (Welfare Quality® Protocol, 2009a). Their feasibility is accepted, but the best location to assess it still needs to be identified, as the milking parlour only allows the observation of vulvar discharges, whereas observations conducted facing the feeding rack only allow recording nasal and ocular vulvar.

We already dealt with cleanliness, as indicator related to comfort around resting (paragraph 2.i). Cleanliness has already been used as welfare indicator in pigs (Scott et al., 2007), poultry (Hughes, 2001) and cattle (Whay et al., 2003). Moreover, cleanliness may be a useful indicator to assess the risk of mastitis in dairy cattle (Hughes, 2001; Reneau et al., 2005; Schreiner and Ruegg, 2003). Studies are needed in order to confirm this finding in goats.

Goats are herd living, gregarious and well synchronized animals (Miranda-de la Lama and Mattiello, 2010). Individuals rarely stay apart from the group (Ross and Berg, 1956). In goats that have been isolated from their social group, blood cortisol concentrations are elevated, and an increase of emotional stress can be observed (Kannan et al., 2002). Isolated animals can be seen in the case of sick or injured occurrence, but in commercial farms this is difficult to realize and observe, due to the high density and space allowance. Nevertheless, the presence of isolated animals can be very interesting as early warning of health problems. These isolated goats generally stand immobile, facing the wall or other parts of the housing structure (Fig. 6). Specific studies are required in order to gather information about this promising indicator and about the way to record it on-farm.

Fig. 6 – Isolated goat

iii) absence of pain induced by management procedures

This welfare criterion is related to the statement that "animals should not suffer pain induced by inappropriate management, handling, slaughter, or surgical procedures (e.g. castration, dehorning)" (Welfare Quality® Protocol, 2009a).

One common management practice in goat farms is ear tagging. If this procedure is not correctly carried out or if ear tags are ripped from the ear, ear tear (full-thickness tear of ear tissue, extending to involve the edge of the ear; Anzuino et al., 2010) may occur, and this probably implies pain. The prevalence of ear tear recorded by Anzuino et al. (2010) was of 6.2% of goats. To our knowledge, this is the only data available on the damage associated with ear tags in goats. Dedicated studies about this potential indicator are needed, as it seems promising to be included for on-farm welfare protocol, because of its supposed feasibility.

Vocalizations and struggles have been collected during both disbudding (Alvarez et al., 2009; Alvarez and Gutiérrez, 2010) and castration (Souad et al., 2011), but being common procedures, the collection of these indicators assumes special relevance during handling procedures in goats, such as blood sampling and rectal palpation (Ndou et al., 2010). Stress related to handling has never been assessed, but it is supposed that the amount and quality of attention of the handler to each individual animal may produce different reactions on goats (Ndou et al., 2010). Up to date, behavioural changes associated with the reaction and the use of local anaesthesia in disbudding kids are not widely investigated, so studies to address an efficient analgesic strategy to protect animal welfare during the disbudding process are required (Alvarez et al., 2009; Alvarez and Gutiérrez, 2010). Behavioural alterations in response to disbudding have been extensively studied in yearling calves, confirming that such procedures induce increases in both the frequency and intensity of pain behaviours (Graf and Senn, 1999; Milligan et al., 2004; Ndou et al., 2010). Cortisol concentrations in blood have been collected to successfully validate struggles and vocalizations in goat kids (Alvarez et al., 2009; Alvarez and Gutiérrez, 2010).

Studies on feasibility and reliability on struggles and vocalizations are needed. No video-recording is possible to use on-farm (Alvarez et al., 2009; Alvarez and Gutiérrez, 2010; Souad et al., 2011), but recording the presence or absence of pain behaviour can be more practical (Ndou et al., 2010), in addition to a sampling strategy during and after the procedure.

4. Appropriate behaviour

This principle is related to the possibility of goats to express social and species-specific behaviours and also to their relationship to humans. The possible indicators for these criteria are presented in Table 5.

Animal-based welfare indicator		Age class [a]	Sex [b]	Attitude [c]	Housing system [d]	Sample size	Validity [e]	Intra-observer reliability [e]	Inter-observer reliability [e]	On-farm feasibility [e]	References
Expression of social behaviours	Rate of agonistic interactions	A/J	F	D	E	96	v	M	-	x	Aschwanden et al., 2009a
	Displacement	A	F	D	E	40	-	-	-	-	Mazurek et al., 2005
		A	F	D	E	35	-	-	-	-	Mazurek et al., 2007
		A	F	D	E	32	v	S	-	v	Andersen et al., 2008
		A	F	D	E	24	v	S	-	v	Andersen and Bøe, 2007
		A	F	D	C	40	x	M	-	v	Loretz et al., 2004
		A	F	D	E	24	x	S	-	v	Ehrlenbruch et al., 2010b
		A/J	F	D	E	70	v	L	-	v	Aschwanden et al., 2009b
		A/J	F	D	E	30	v	S	-	v	Ehrlenbruch et al., 2010a
		K	F/M	.	E	30	v	M	-	v	Van et al., 2007
		A	F	D	E	15	v	M	-	v	Fernandez et al., 2007
		A	F	D	E	55	v	M	-	v	Nordmann et al., 2011
	Rate of displacements received whilst feeding	A/J	F	D	E	70	x	L	-	x	Aschwanden et al., 2009b
	Rate of agonistic interactions initiated whilst feeding	A/J	F	D	E	70	x	L	-	x	Aschwanden et al., 2009b
	Supplanting	A	F	D	E	40	-	-	-	-	Mazurek et al., 2005
		A	F	D	E	35	-	-	-	-	Mazurek et al., 2007
	Frightening	A	F	D	E	40	-	-	-	-	Mazurek et al., 2005
		A	F	D	E	35	-	-	-	-	Mazurek et al., 2007
	Assaulting	A	F	D	E	40	-	-	-	-	Mazurek et al., 2005
		A	F	D	E	35	-	-	-	-	Mazurek et al., 2007
	Fight	A	F	D	E	35	-	-	-	-	Mazurek et al., 2007
	Exploring	A	F	D	E	32	v	S	-	x	Andersen et al., 2008
		A	F	D	E	24	x	S	-	x	Andersen and Bøe, 2007
	Frontal clash	A	F	D	E	32	v	S	-	x	Andersen et al., 2008
		A	F	D	E	24	x	S	-	x	Andersen and Bøe, 2007
		A/J	F	D	E	96	v	M	-	x	Aschwanden et al., 2009a
	Butt	A/J	F	D	E	96	v	M	-	x	Aschwanden et al., 2009a
		A	F	D	E	32	v	S	-	x	Andersen et al., 2008

		A	F	D	E	24	x	S	-	x	Andersen and Bøe, 2007
		A	F	D	E	24	x	S	-	x	Ehrlenbruch et al., 2010b
		A	F	D	E	60	x	S	-	x	Laporte-Broux et al., 2011
		A	F	D	E	55	x	M	-	x	Nordmann et al., 2011
		A	F	D	E	15	v	M	-	x	Fernandez et al., 2007
	Chase	A	F	D	E	32	v	S	-	x	Andersen et al., 2008
		A	F	D	E	24	x	S	-	x	Ehrlenbruch et al., 2010b
		A	F	D	E	24	x	S	-	x	Andersen and Bøe, 2007
		A	F	D	E	60	x	S	-	x	Laporte-Broux et al., 2011
		A	F	D	E	15	v	M	-	x	Fernandez et al., 2007
	Threat	A	F	D	E	32	v	S	-	x	Andersen et al., 2008
		K	F/M	.	E	30	v	M	-	x	Van et al., 2007
		A	F	D	E	15	v	M	-	x	Fernandez et al., 2007
		A	F	D	E	24	x	S	-	x	Andersen and Bøe, 2007
		A/J	F	D	E	96	v	M	-	x	Aschwanden et al., 2009a
		A	F	D	E	60	x	S	-	x	Laporte-Broux et al., 2011
	Push	A	F	D	E	24	x	S	-	x	Ehrlenbruch et al., 2010b
		A	F	D	E	55	x	M	-	x	Nordmann et al., 2011
		K	F/M	.	E	30	v	M	-	x	Van et al., 2007
	Bite	A	F	D	E	55	x	M	-	x	Nordmann et al., 2011
		A	F	D	E	15	v	M	-	x	Fernandez et al., 2007
	Horn kick	A	F	D	E	55	x	M	-	x	Nordmann et al., 2011
	Levering outs	A	F	D	E	55	x	M	-	x	Nordmann et al., 2011
	Hits	A	F	D	E	55	x	M	-	x	Nordmann et al., 2011
	Avoidance	A	F	D	E	32	v	S	-	x	Andersen et al., 2008
		A/J	F	D	E	70	x	L	-	x	Aschwanden et al., 2009b
		A	F	D	E	60	x	S	-	x	Laporte-Broux et al., 2011
	Withdrawal	A	F	D	E	24	x	S	-	x	Andersen and Bøe, 2007
		A	F	D	E	32	v	S	-	x	Andersen et al., 2008
		A	F	D	E	24	x	S	-	x	Ehrlenbruch et al., 2010b
	Vocalizations	J	F	.	E	48	v	S	-	x	Siebert et al., 2011
		A	F	D	E	40	-	-	-	-	Mazurek et al., 2005
		A	F	D	E	40	-	-	-	-	Mazurek et al., 2007
	Self-grooming	A	F	D	E	60	v	S	-	x	Laporte-Broux et al., 2011
	Positive interactions	A	F	D	E	60	v	S	-	x	Laporte-Broux et al., 2011
	Sniff/glance to a stimulus	A	F	D	E	40	-	-	-	x	Mazurek et al., 2007
		A	F	D	E	40	-	-	-	x	Mazurek et al., 2005
	Moving	A	F	D	E	40	-	-	-	x	Mazurek et al.,

											2007
	Locomotion	J	F	.	E	48	v	S	-	x	Siebert et al., 2011
	Standing	J	F	.	E	48	x	S	-	x	Siebert et al., 2011
	Lying	J	F	.	E	48	x	S	-	x	Siebert et al., 2011
	Rearing	J	F	.	E	48	v	S	-	x	Siebert et al., 2011
	Jumping	J	F	.	E	48	x	S	-	x	Siebert et al., 2011
	Eliminatory behaviour	A	F	D	E	40	-	-	-	x	Mazurek et al., 2005
		A	F	D	E	40	-	-	-	x	Mazurek et al., 2007
	Social test	K	F/M	.	E	16	x	S	-	x	Andersen et al., 2008
	Novel object test	K	F/M	.	E	16	x	S	-	x	Andersen et al., 2008
	Feeding simultaneously	A/J	F	D	E	96	v	M	-	x	Aschwanden et al., 2009a
		A	F	D	E	55	v	M	-	x	Nordmann et al., 2011
	Duration of the first simultaneous feeding bout	A/J	F	D	E	96	v	M	-	x	Aschwanden et al., 2009a
	Length of feeding bouts interrupted due to a social reason	A/J	F	D	E	70	v	L	-	x	Aschwanden et al., 2009b
	Number of times goat visited the feeder	A	F	D	E	15	x	M	-	x	Fernandez et al., 2007
Expression of other behaviours	Excessive grooming	A	F	D	C	11403	-	-	-	-	Anzuino et al., 2010
	Abnormal oral behaviour	A	F	D	C	11403	-	-	-	-	Anzuino et al., 2010
Good human-animal relationship	Avoidance distance test	A	F	D	C	271	O	-	-	v	Mattiello et al., 2010
	Emotional reactivity	A	F	.	E	40	-	-	-	-	Mazurek et al., 2005
	Emotional reactivity	A	F	.	E	40	-	-	-	-	Mazurek et al., 2007
	Vocalization scorings	J	M	Me/D	E	48	-	M	-	-	Ndou et al., 2010
	Pen scoring	J	M	Me/D	E	48	-	M	-	-	Ndou et al., 2010
	Crush score	J	M	Me/D	E	48	-	M	-	-	Ndou et al., 2010
	Flight speed	J	M	Me/D	E	48	-	M	-	-	Ndou et al., 2010
	Flight time	J	M	Me/D	E	48	-	M	-	-	Ndou et al., 2010
	Encounter test	K	M/F	.	E	26	x	M	-	x	Boivin and Braastad, 1996
	Choice test	K	M/F	.	E	26	x	M	-	x	Boivin and Braastad, 1996
	Latency test	A	F	D	C	16	v	S,M	-	v	Jackson and Hackett, 2007
	Vocal repetition rates	K	F	D	E	14	x	S	-	x	Lyons and Price, 1987
	Avoidance behaviour test	K	F	D	E	14	v	S	-	x	Lyons and Price, 1987
	Stationary human encounter test	K	F	D	E	30	v	L	-	x	Lyons et al., 1988
	Moving person encounter test	K	F	D	E	30	v	L	-	x	Lyons et al., 1988
	Novel object test	K	F	D	E	30	v	L	-	x	Lyons et al., 1988
Positive emotional state	Velocity of moving	A	F	D	E	5	x	S	-	x	Van der Staay et al., 2011
	Percentage time moving	A	F	D	E	5	x	S	-	x	Van der Staay et al., 2011
	Lying	A	F	D	E	5	x	S	-	x	Van der Staay et al., 2011
	Standing	A	F	D	E	5	x	S	-	x	Van der Staay et al., 2011
	Eliminatory behaviour	A	F	D	E	5	x	S	-	x	Van der Staay et al., 2011
	Eating/drinking	A	F	D	E	5	x	S	-	x	Van der Staay et al., 2011
	Alertness	A	F	D	E	5	x	S	-	x	Van der Staay et al., 2011
	Horn kick	A	F	D	E	55	x	M	-	x	Nordmann et al., 2011

	Push	A	F	D	E	55	x	M	-	x	Nordmann et al., 2011
	Levering outs	A	F	D	E	55	x	M	-	x	Nordmann et al., 2011
	Hits	A	F	D	E	55	x	M	-	x	Nordmann et al., 2011
	Bite	A	F	D	E	55	x	M	-	x	Nordmann et al., 2011
	Butt	A	F	D	E	55	x	M	-	x	Nordmann et al., 2011
	Displacement	A	F	D	E	55	v	M	-	x	Nordmann et al., 2011
	Alert sound	.	.	.	.	.	.	.	.	.	.
	Qualitative behaviour assessment	.	.	.	.	.	O	.	.	v	.

Table 5 – Animal-based indicators for assessing "appropriate behaviour", excluding physiological measurements. [a] Age class: "A" Adult (>6 months), "J" Juvenile (3-6 months), "K" Kid (<3 months). [b] Sex: "M" Male, "F" Female. [c] Attitude: "D" Dairy, "Me" Meat, "F" Fiber. [d] Housing system: "C" Commercial farm, "E" Experimental farm. [e] Validity, reliability, feasibility: "v" tested and valid or reliable or feasible, "x" tested and not valid, not reliable or not feasible, "-" not tested, "O" validity assessed in other species; "S" short-term reliability, "M" mid-term reliability, "L" long-term reliability.

i) expression of social behaviours

In gregarious animals like goats, that usually are housed in group pens, social behaviour is very important, and the possibility to "express a normal, non-harmful, social behaviour (e.g. allo-grooming)" (Welfare Quality® Protocol, 2009a) should always be guaranteed.

Many aspects of social behaviour can be considered. For example, social isolation represents a stressful challenge, which can impair animal welfare in gregarious species. However, in captive animals, there is often a need to temporarily separate an individual from its group, e.g., for veterinary inspection, management or experimental procedures (Mazurek et al., 2005, 2007; Siebert et al., 2011). Another frequent procedure is regrouping, that is a common practice in herd management. Regrouping results in social instability and leads to an increase in aggressive interactions (as recently reviewed by Miranda-de la Lama and Mattiello, 2010), suggesting a temporal disruption of the social structure of the herd. High levels of aggressions may appear during the first day of regrouping, followed by a decrease in 3 days (Andersen et al., 2008; Fernandez et al., 2007). Aggressions in a herd can also be prompted by the lack of resources (feed, water, lying space) or reduced space allowance (Andersen and Bøe, 2007; Ehrlenbruch et al., 2010a; Jørgensen et al., 2007; Laporte-Broux et al., 2011; Loretz et al., 2004; Van et al., 2007). Many papers also take into account the effect of structural modifications on goats' social behaviour (Aschwanden et al., 2009a, 2009b; Ehrlenbruch et al., 2010b).

Compared to other female ungulates, goats are reported to have a significantly higher rate of aggressive interactions (Fournier and Festa-Bianchet, 1995). Although some researchers have found a clear, linear dominance structure in groups of goats (Addison and Baker, 1982; Barroso et al., 2000), others claim that the hierarchic system may be less clear and more dynamic (Scott, 1948; Fournier and Festa-Bianchet, 1995). The use of social behaviour (especially agonistic behaviour) as a welfare indicator is a controversial question. Feasibility is quite difficult to accept: a long time is usually required to obtain reliable information and direct observations are rarely performed (Nordmann et al., 2011). Many factors (e.g. age, dominance, horned and hornless goats, pregnant or lactating goats, sample size) can influence the agonistic behaviour; therefore this indicator does not give very specific information on the welfare status of the animals. Probably the more feasible indicator to assess the reaction of goats during resource competition is displacement, as already reported (paragraph 1.i). Validity has been assessed in many papers (Andersen and Bøe, 2007; Andersen et al., 2008; Aschwanden et al., 2009b; Ehrlenbruch et al., 2010a; Van et al., 2007), but Fernandez et al. (2007) also found a concurrent validity by changes in milk production.

Vocalisations are another common expression of social behaviour in goats and they are used to communicate between animals. Increased vocal responses in situations of social isolation can be interpreted as either an adaptive attempt to communicate with companions or a sign of distress and fear, making the use of this indicator unclear (Siebert et al., 2011).

ii) expression of other behaviours

As to other behaviour, we mean the possibility "to express species-specific natural behaviours such as foraging" (Welfare Quality® Protocol, 2009a). Therefore, the presence of behaviours that are not species-specific under natural conditions, or that are performed with unnatural frequency, can be regarded as a sign of poor welfare. In this view, excessive scratching or rubbing and abnormal oral behaviour could be considered as promising indicators of a poor welfare condition. Their validity has never been specifically assessed in goats, but several studies are available to support their use in other species (e.g. pig: Brunberg et al., 2011; Welfare Quality® Protocol, 2009b; dairy cattle: Kamboj et al., 2007; Welfare Quality® Protocol, 2009a). Moreover, for group observations, the prevalence of excessive scratching was found to be positively correlated with the prevalence of body skin lesions (Anzuino et al., 2010).

Behaviours such as oral manipulation of inert objects are potential welfare issues worthy of further investigation on some farms. When given the opportunity, goats feed predominantly by browsing, and oral behaviours are likely to be important for their welfare. Possible motivations include normal investigatory behaviour, frustration or redirected feeding behaviour. Studies on captive giraffes, another browsing animal, suggest that a lack of roughage in the diet (Baxter, 2001) and the method of feeding (Bashaw et al., 2001) may contribute to the development of abnormal oral behaviours, and that these behaviours may become stereotypical (Bashaw et al., 2001; Baxter, 2001). According to Anzuino et al. (2010), abnormal oral behaviours in goats are mainly directed at the bars (found in 91.7% of farms) or walls of pen structures (83.3%); this author recorded no case of abnormal oral behaviour directed at teats. However, abnormal oral behaviour directed at teats is commonly observed in other ruminant species, like veal calves (Margerison et al., 2003). The fact that no goats have been found performing oral behaviour on teat in the presented study can be related to different possibilities, which bring out some problems related to the feasibility of this indicator. In fact, problems of feasibility to record this indicator are related to the fact that direct observations required time (e.g. long observation period) and perfect timing (i.e. just before feeding time), but difficulties in noticing the behaviour in large groups should be borne in mind. A sampling strategy is strongly required.

iii) good human-animal relationship

This criterion is based on the assumption that "Animals should be handled well in all situations, i.e. handlers should promote good human-animal relationships" (Welfare Quality® Protocol, 2009a).

Behaviour tests that measure animals' reactions to humans enable us to gain information about their level of fear determined by the quality and frequency of the previous human–animal interactions (Waiblinger et al., 2006). Moreover, many published studies provide proof of the major effect of stockmanship on animal production (Hemsworth, 2003) and welfare (de Passillé and Rushen, 2005). Nevertheless, the effect of the quality of human–animal relationship on productive traits and welfare has been scarcely investigated in goats. Human–animal behaviour tests are important indicators to include in on-farm welfare assessment schemes. Tests performed in experimental arena, which require moving the animals outside the home pen, have been excluded (Lyons and Price, 1987; Lyons et al. 1988), due to their unfeasibility. The promising tests that we found belong to two main categories: reaction to a stationary man and reaction to a moving man. In the approach test performed by Jackson and Hackett (2007) to evaluate the effect of a gentle handling treatment, the experimenter stops in the middle of the pen and begins timing the latency for each animal to approach within 60 cm: the gentled goats approached the experimenter and habituated more quickly compared to the control goats, confirming the validity of this test. This finding has also been confirmed in other species, such as cattle (Breuer et al., 2000; Hemsworth et al., 2000; Jago et al., 1999; Lensink et al., 2000).

As reaction to a moving man, the avoidance distance test performed by Mattiello et al. (2010) gave interesting results. In this test, using the methodology already validated in cattle (Welfare Quality®

Protocol, 2009a), the experimenter moves in the pen approaching individual goats and measuring the avoidance reaction, in term of distances. Validity on goats has not been definitively assessed yet, but the results were similar to those obtained in cattle, although some modifications to the test for cattle were suggested in the conclusions, considering the different attitude towards humans between goats and cows. In fact, goats seem more confident with man, and frequent physical contacts between the animals and the observer occurred during the test.

Both tests are easy to perform, but the avoidance distance test requires more training in order to assess distances and recognize possible confounding factors. Moreover, avoidance distance test is more time consuming compared to latency to approach test. The feasibility of the avoidance distance test needs to be confirmed in large farms, as Mattiello et al. (2010) only considered relatively small farms. On the other hand, the latency to approach test may be enriched by more information to collect during the stationary period, such as the number of animals in contact or in proximity of the observer, at a given period. Dominance between goats should be taken into account during the test execution: it is likely to be assumed that dominant goats come into contact with man, so recording also the animals in a larger radius can be more informative and effective.

Although behavioural test for assessing human-animal relationship seem to be valid, as well as feasible and reliable (sheep, Napolitano et al., 2011; beef heifers, Mazurek et al., 2011; buffalos, De Rosa et al., 2005; dairy cows, Rousing et al., 2004), they require time, training, and partly induce stress to the animals, hence the development of less intrusive but still valid indicators would be useful. To this aim, a possible indicator that might be evaluated is snorting, which is a peculiar alert call emitted by goats. It consists of a loud, short and abrupt sound, produced to warn the group or the pen mates about an imminent danger detected. This vocalization is made with the mouth closed while the goat forcefully expels a single blast of air primarily through the nostrils. The use of this sound as indicator of elicited fear by humans needs to be validated, but it should be very interesting to apply for on-farm welfare assessment.

iv) positive emotional state

This last criterion is very difficult to approach, due to the amount of negative emotion expressed by animals during their farmed life, and it is based on the concept that "Negative emotions such as fear, distress, frustration or apathy should be avoided whereas positive emotions such as security or contentment should be promoted" (Welfare Quality® Protocol, 2009a).

The only promising indicators identified to explore positive emotional state is Qualitative Behaviour Assessment (QBA). QBA is a whole-animal approach, in which the observer can integrate perceived behavioural details and signals to judge an animal's behavioural expression, using qualitative descriptors (e.g. relaxed, anxious) that reflect the animals' emotional state (Wemelsfelder, 2007). Studies on many species, such as horse, pigs and sheep (Minero et al., 2009; Rutherford et al., 2012; Wemelsfelder et al., 2009), have shown that data generated from such observations are reliable and repeatable, and correlate to assessments of the animal's physical behaviour.

CONCLUSIONS

Our review highlights some aspects of goats' welfare that have been largely investigated, but also shows some lacks in the scientific research. Most of the studies have been performed on adult dairy goats that represent the main category bred in Europe. The first approach to this widespread category seems well justified, but further studies are needed to cover welfare indicators also in kids and bucks. Also meat and fibre goats have often been neglected, but probably some considerations can be successfully extrapolated from dairy goats. Most of the studies carried out so far have been performed in experimental farms, so the feasibility in commercial situation of the indicators adopted in these studies needs to be carefully evaluated. Our list of promising indicators took into account this issue, highlighting the need for further studies, as the feasibility of some indicators has never been assessed. As to behavioural indicators, in the researches presented in this review most of them have been collected by video-recording and not by direct observations and this makes them not suitable for our purposes. This is the reason why we frequently stressed the idea of applying an effective sampling strategy and simplified point scales to record data on-farm.

Short-term intra-observer reliability has frequently been assessed, and some studies also consider mid- and long-term reliability. This issue is very important, as the consistency throughout time of indicators is crucial in welfare assessment protocols, that need to be used at any time. In contrast, the inter-observer reliability has almost never been assessed. Further studies are needed to include information about this issue, as a reliable data collection should necessarily be supported by a high accordance among observers. Easy-to-perform observations or simplified point scales may help to obtain higher levels of agreement.

As expected, indicators related to health and disease are the more represented, whereas indicators related to other principles need to be further investigated.

This review is supposed to be a starting point into the research of animal-based indicators in goats, but further studies are needed in order to confirm the already existing results and to improve the development of effective on-farm welfare assessment protocols.

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Chapter 4

AVOIDANCE DISTANCE TEST IN GOATS: A COMPARISON WITH ITS APPLICATION IN COWS

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Published in: Small Ruminant Research 91 (2010): 215–218

A B S T R A C T - The present study investigates the feasibility in goats of an avoidance distance (AD) behaviour test set-up for cattle, and compares the results in the two species to assess the suitability of the test for on-farm welfare evaluation in goat farms. The tests were performed on 324 lactating cows (170 in small farms and 154 in large farms) and 271 lactating goats (108 in small farms and 163 in large farms), housed in free stall farms (12 dairy cattle and 17 dairy goat farms) in the Province of Sondrio, Northern Italy, following a protocol validated for dairy cows in the Welfare Quality® project. After the assessors were adequately trained, this test was relatively easy to perform and no major difficulties were faced in either species. Goats exhibited a higher level of confidence with humans, as showed by lower AD (goats: 68.60±4.98 cm; cows: 71.36±4.37 cm; $p < 0.10$) and higher frequency of contacts (AD = 0) (goats: 45.8%; cows: 31.2%; $p < 0.001$). Farm size significantly affected AD values (lower in small farms) and frequency of contacts (higher in small farms) in goats, but not in cows. This was probably due to the less marked management difference between large and small farms of cattle than those of goats. The AD test seems feasible in goats; however, the experimenter contacted nearly half of the goats. To improve the sensitivity, a further level – represented by the possibility of gently stroking the goat's head after the contact – may be included in the test in addition to contact.

Keywords: human–animal relationship, dairy cattle, goats, welfare, behaviour

INTRODUCTION

Many published studies provide proof of the major effect of stockmanship on animal production (Hemsworth, 2003) and welfare (de Passillé and Rushen, 2005). Veal calves and dairy cows handled with additional positive human contact show fewer stress responses to handling than controls (Lensink et al., 2000; Waiblinger et al., 2002), whereas cattle fearing humans show acute and chronic stress signs as well as reduced productivity (Rushen et al., 1999; Breuer et al., 2003). The effect of the quality of human–animal relationship on productive traits and welfare has been scarcely investigated in goats. In dairy goats, Jackson and Hackett (2007) found no positive effect of gentling on milk fat and protein concentrations; however, a significant increase of body weight (indirectly assumed by heart girth measurements) was observed by the same authors in response to a short gentling treatment. Lyons (1989) recorded lower levels of milk ejection impairment (lower residual milk volumes) in human-reared than in dam-reared goats. Besides having positive effects on production, a better human–animal relationship (for example in response to gentling treatments) can positively affect goats' reactions to handling and makes the animals less fearful, thus facilitating husbandry operations (Boivin and Braadstad, 1996). The way that animals are handled, as well as the frequency of human–animal interactions, influences the nature of the human–animal relationship on farm and can be reflected in the behavioural responses of animals to humans during specific tests (Hemsworth et al., 2000; Boivin et al., 2003; Waiblinger et al., 2006). Behaviour tests that measure animals' reactions to humans enable us to gain information about their level of fear determined by the quality and frequency of the previous human–animal interactions. For example, cattle show more intense fear responses to humans in larger farms with higher levels of mechanization, due to the lower frequency of contacts with the stockperson (Mattiello et al., 2009). Human–animal behaviour tests are important parameters to include in on-farm welfare assessment schemes and can be classed into three large categories: reactions to a stationary human, reactions to a moving human and responses to actual handling (Waiblinger et al., 2006). The avoidance distance test measures the distance at which an animal withdraws from an approaching human; its validity as a welfare indicator has been verified in dairy cows by correlating the flight distances to stockmen behaviour and to other human–animal tests. It has been proven that the different variables were conceptually related and that the repeatability and the inter-observer reliability of the avoidance distance test were satisfactory (Windschnurer et al., 2009a). In dairy goats, an attempt to measure human–animal relationship was experimented by Lyons (1989) using a stationary human, a moving human and a pursuing human test. The response of the animals was measured only in terms of time (latency to proximity, time in proximity and latency to contact); no avoidance distance was recorded in these tests. Jackson and Hackett (2007) also measured human–animal relationship in adult dairy goats using a latency to approach test. Lyons and Price (1987) recorded the time in contact with an unknown experimenter in a test pen as a measure of avoidance behaviour to humans. Some measure of human-goat distance was taken by Lyons et al. (1988) in a test arena. Most of these measurements require movement of the animals from their home pen. Therefore they cannot be included in on-farm welfare evaluation schemes. However, this sort of evaluation is being requested more often, in view of future certification requirements which are presently raising the attention of the European Agricultural Policy (European Commission, 2009). In order to obtain useful information for the evaluation of human–animal relationship on goat farms in the frame of an on-farm welfare evaluation scheme, the present study investigates the feasibility in goats of an avoidance distance behaviour test set-up for cattle, and compares the results from the two species.

MATERIALS AND METHODS

The study was carried out in 12 dairy cattle and 15 dairy goat free stall farms located in the Province of Sondrio, Northern Italy. Goat breeds were Saanen, Camosciata, Frisa and Bionda dell'Adamello; cattle breeds were Brown Swiss, Bruna and Italian Holstein Friesian. The number of breeding females in these farms ranged from 9 to 194 (mean ± s.e. = 67.0 ± 15.2) in goat farms and from 30 to 200 in cattle farms (mean ± s.e. = 69.1 ± 14.5). Depending on farm size, the farms were classed as small (up to 50 breeding females) or large (more than 50 breeding females) (Table 1).

		No. of farms	No. of animals tested	Mean±s.e. (min–max)
Goat farms	Small	8	108	26.9 ± 4.71 (9–46)
	Large	7	163	112.9 ± 21.6 (55–194)
Cattle farms	Small	7	170	40.9 ± 2.1 (30–48)
	Large	5	154	108.6 ± 26.7 (60–200)

Table 1 - Number of farms surveyed, number of animals tested and descriptive statistics of the number of breeding females in the farms, divided by species (goat or cattle) and by farm size (small and large).

In goat farms, manual interventions are still quite frequent: manure removal is done manually in 3/4 and milking in 1/3 of small farms. However, both interventions are mechanical in large goat farms. In cattle farms, regardless of their size, both manure removal and milking are mechanical. Sample size depended on herd size and, in any case, the proportion of tested animals was never lower than 40% (Welfare Quality®, 2009). Avoidance distance (AD) tests to an unknown person were performed on 324 lactating cows and 271 lactating goats (once for each animal), following a protocol validated for dairy cows in the Welfare Quality® project (Windschnurer et al., 2009b). The observer (who had been previously specifically trained) entered the home pen and stood in front of the animal at a distance of 3m, established a reciprocal visual contact with the animal, then started to move slowly towards the animal at a speed of one step/s, 60 cm/step and the arm lifted with an inclination of 45◦, the hand palm directed downwards, without looking into the animal's eyes, but looking at the muzzle. When the animal showed the first avoidance reaction (moving backwards, turning or shaking its head), the observer recorded the AD as the distance from his hand and the muzzle of the animal, with a definition of 10 cm. This distance was estimated by sight; the accuracy of the estimates had been previously assessed during the training period. If the animal could be touched by the observer AD was 0, and this was defined as "contact". Data were submitted to Kolmogorov–Smirnov test to verify the normality of the distribution. The effect of species (cows *vs* goats) and of farm size (small *vs* large) were investigated by means of non-parametric analysis of variance (Kruskal–Wallis test) for AD mean comparisons and by Chi square test for the comparison of frequency distribution of contacts.

RESULTS AND DISCUSSION

Training was essential in order to carry out the tests properly, assess distances and recognize possible confounding factors as disturbance by other animals or specific motivational states that could affect the animals' reactivity. The test was relatively easy to perform and no major difficulties were faced in either species. AD data did not satisfy the assumptions of a normal distribution (mean ± s.e. = 70.10 ± 3.29 cm, min=0cm, max= 300 cm, inter-quartile range = 120 cm, skewness= 0.862, kurtosis =−0.613; Kolmogorov–Smirnov test: df = 595, $p < 0.001$), therefore they were submitted to non-parametric analysis of variance. AD was lower in goats (n = 271, mean ± s.e. = 68.60±4.98 cm) than in cows(n = 324, mean ± s.e. = 71.36±4.37 cm) and this difference approached statistical significance (Kruskal–Wallis Chi2 = 2.87, df = 1, $p < 0.10$). The maximum AD recorded in cows was 300 cm, while in goats it was only 200 cm. The frequency of contacts was significantly higher in goats (124 out of 271, 45.8%) than in cows (101 out of 324, 31.2%) (Pearson $Chi^2 = 13.35$, df = 1, $p < 0.001$). This suggests that goats have a higher level of confidence with humans. Goats are generally described as a curious and highly reactive species, which often tends to exhibit exploratory behaviour (Kilgur and Dalton, 1984; Houpt, 2005). This may be one of the factors explaining the lower AD and higher frequency of contacts recorded in this species. Furthermore, in goat farms the management practices are often based on manual procedures (e.g. for manure removal and sometimes also for milking), and this may have positively affected goats' level of confidence and lead to a lower level of fear in animals more accustomed to human contact. This is supported by the fact that significant differences depending on farm size were found in goats, but not in cows (Table 2; Fig. 1). Consistent with these results, the percentage of contacts was affected by farm size only in goats (70.4% of contacts in small farms *vs* 29.4% of contacts in large farms; Pearson Chi^2 = 43.83, df = 1, $p < 0.001$), while no difference was recorded in cows (32.4% of contacts in small farms *vs* 29.9% of contacts in large farms; n.s.). This might be due to the fact that the level of mechanization in cattle farms is always high, even in small farms. Therefore, management differences between large and small farms in cattle are less marked than in goats, and this might explain the lack of significant differences in our cattle farms. It has to be remarked that, under different circumstances (with more marked differences related to the level of mechanization), significant AD differences were found in cattle depending on the type of management and on farm size (Mattiello et al., 2009). Our results in goats are further supported by earlier research reporting shorter avoidance distances in goats that were reared in small old farms than in large modern farms (Mattiello et al., 2008), in response to different farm size and level of mechanization. Frequent manipulation of the goats during daily activities seems to play a major role in reducing fear responses towards humans.

	Small farms	Large farms	Chi^2	Significance
	Mean±s.e. (min–max)			
Goats AD (cm)	29.07±5.75 (0–200)	94.79±6.61 (0–200)	47.71	$p < 0.001$
Cows AD (cm)	73.74±6.30 (0–300)	68.73±6.03 (0–250)	0.03	n.s.

Table 2. Sources of and results of statistical analyses of avoidance distance (AD) data from goats and cattle from farms differing in herd size.

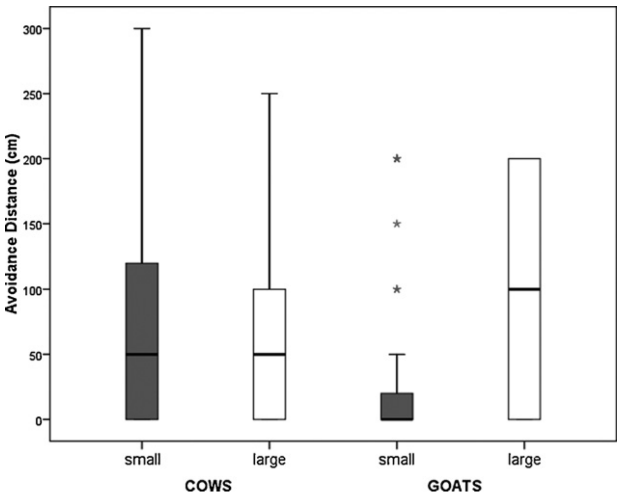

Fig. 1. Box plots showing the distribution of avoidance distance (AD) in small and large farms of goats and cows. The figure reports the median, the25th and 75th percentiles, and the minimum and maximum observed values that are not statistically outlying. Extreme values (points at a greater distance from the median than 3 times the inter-quartile range) are also highlighted in the figure with an asterisk (*).

CONCLUSIONS

The AD test seems feasible in goats and was able to detect differences depending on farm size and, consequently, on management practices. Compared to cows, goats seemed generally more confident with man, and physical contact between the animals and the observer was more frequent than in cows. The starting distance for performing AD test in goats might therefore be reduced to 2m, instead of the 3mdefined for cattle. Furthermore, as nearly half of the goats got in contact with the experimenter, in order to improve the test sensitivity a further level – which might be termed as "acceptance" – may be included in the test in addition to contact. The test would then include three levels: avoidance (ranging from 10 to 200 cm), contact (followed by immediate withdrawal) and acceptance (after the contact, the animal accepts gently stroking of the head).

ACKNOWLEDGEMENTS - We are grateful to all the farmers who collaborated with this research and to the Farmers' Association of the Province of Sondrio (APA), especially Germana Cioccarelli that helped us to contact the farmers and gave us useful advice during this study. We also thank Samuele Villa for his valuable help during field work. This research was partially funded by PUR 2008.

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Chapter 5

PRELIMINARY STUDY ON THE USE OF HAIR COAT CONDITION AS INDICATOR FOR ON-FARM WELFARE ASSESSMENT IN GOATS*

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To be submitted

**Preliminary results have been already presented: Battini M., Grosso L., Barbieri S., Ajuda I., Vieira A., Stilwell G., Mattiello S. Le condizioni del mantello sono un valido indicatore di benessere nella capra?* Proceedings of *XX Congresso Nazionale S.I.P.A.O.C., 26-29 September 2012, Siracusa (Italy).*

ABSTRACT – The aim of this preliminary study is to gather information about the possibility of including the hair coat condition as an animal-based indicator for on-farm welfare assessment protocol in goats. The experiment was initially performed in Portugal, and then repeated in Italy, in order to increase the sample size and to test the validity of this indicator in different farming conditions. The results were comparable between the two repetitions and are therefore presented together. Two homogeneous groups of 24 adult dairy goats with rough hair (RH: rough or scurfy hair) and 24 goats with normal hair (NH: shiny and sheen hair) were subjected to general clinical examination, evaluation of BCS, collection of hair, blood and faecal samples and skin scraping. RH goats showed a significantly poorer body condition compared to NH goats, with a higher percentage of too thin goats by sternum area palpation ($p < 0.01$) and by lumbar area palpation ($p < 0.001$). Moreover, RH goats showed a higher prevalence of abnormal lung sounds compared to NH goats ($p < 0.001$). Preliminary results are encouraging to state that the hair coat condition can be a valid and feasible indicator of goat welfare, that may be included in on-farm welfare assessment protocols, although its repeatability and reliability still have to be investigated.

Keywords: hair coat, welfare assessment, health condition, goats

INTRODUCTION

Hair coat condition can be considered a promising indicator of animal health and welfare. Besides predictable factors such as parasites and skin infections, hair condition may also reflect internal or systemic diseases. Endocrine dysfunctions and nutritional deficiencies, as well as pregnancy or organic disorders, fever, immune-mediated diseases and general severe illness may influence the growth of hair and adversely affect hair coat condition (Kahn et al., 2006).

The hair coat may be influenced by different reasons. Common ecto-parasites of animals are ticks, lice, fleas, and mites (Huq and Mollah, 1972; Kader and Huq, 1973; Nooruddin and Dey, 1989; Nooruddin and Mondal, 1996; Rahman and Mondal, 1985). The damage brought by ecto-parasites causes blood loss, skin irritation, as well as annoyance to the animals. Due to the presence of parasitic infestation, feeding and digestion processes may be altered, leading to slow growth, loss of weight and reduced milk or meat production. Furthermore, infested goats may bite and rub the involved area to the point of abrading the skin. Veit et al. (1993) reported that goats infested by ecto-parasites showed a dull hair coat with dry, flaky skin or presence of dandruff.

Also nutritional deficiencies (especially phosphorus, zinc, copper, vitamin A and vitamin E deficiency), that may also contribute to infertility and reduced growth of goats, seem to affect hair coat and skin conditions (Veit et al., 1993). Moreover, mineral deficiencies in the diet may accentuate parasitic infestation, leading to severe clinical signs of diseases (Szefer and Nriagu, 2007).

Hair coat condition may be a suitable indicator for on-farm welfare assessment. A study performed by Lengarite et al. (2012) proved that most farmers can identify mineral deficiencies and adequacies in their herd by visual assessment. In that study, the indicators of mineral adequacies were healthy appearance, shiny skin and fatness, while those of mineral deficiencies were poor health conditions, rough hair coat, pica and slow growth.

A study performed by Pritchard et al. (2005) on working horses, donkeys and mules found that 8% of animals showed a very poor health condition, which was related to an inadequate hair coat condition, described as matted, dry, and uneven hair, as well as to abnormal mucous membranes, missing teeth and ecto-parasites.

Hair coat condition scoring systems are currently applied for the evaluation of captive animal welfare. Institutional Animal Care and Use Committees (IACUC) in the United States score alopecia as simply present or absent, whereas different point scales have been suggested by Wolfensohn and Lloyd (2003) and Berg et al. (2009). Berg et al. (2009) underline that recording hair coat condition may play an important role in welfare assessment, as early detection of health problems, even where no pathology is expected to occur (Berg et al., 2009).

Up to date, the evaluation of the hair coat condition has not yet been used in goats. The aim of this preliminary study is to gather information about the possibility of using this indicator to include in on-farm welfare assessment protocol.

MATERIALS AND METHODS

This research was carried out in two commercial dairy goat farms, one in Portugal and one in Italy. Two repetitions were performed in order to increase the sample size and to test the validity of hair condition as animal-based welfare indicator in different farming environments. The research conducted in Portugal was performed in a very large farm (1.000 goats) in the region of Benavente (Central Portugal) in June 2012, while in Italy the study was conducted in a large farm (300 goats) in the Province of Sondrio (Northern Italy) in December 2012. In both repetitions, Saanen goats were evaluated and allocated to group with rough hair coat (RH) or group with normal hair coat

(NH). The goats' age, number of days in milking and number of deliveries were similar between the two groups. RH goats were described as animals with some or all of the hair matted, rough or scurfy; the hair appears longer than normal (Fig. 1). NH goats were described as animals presenting shiny and sheen hair, homogeneous and adherent to the body (Fig. 2). Both in RH and NH goats, the hair coat condition was assessed considering the whole body (both sides), with the exception of head and legs below the joints (knees and elbows). A previous training of the assessor was performed by visual assessment and photographic material in order to properly detect RH and NH goats. Cleanliness was not considered in the evaluation of hair condition.

Fig. 1 – Goat with rough hair coat

Fig. 2 – Goat with normal hair coat

The final sample was formed by 24 RH and 24 NH goats (15 in Portugal and 9 in Italy for each group). All the animals were subjected to a general clinical examination, including measurement of rectal temperature, heart rate, respiratory rate, visual evaluation of mucosae colour (normal, anaemic, hyperaemic), auscultation of ruminal sounds (present, absent) and lung sounds (normal, abnormal). In addition, body condition was assessed by palpation of sternum and lumbar area (BCS: 0=too thin; 1=normal; 2=too fat) and the presence of external abscesses was recorded. Hair and blood samples were collected to evaluate mineral deficiencies (Franzmann et al., 1975; Moraes, 2001; Pavlata et al., 2011): 2-3 gr of hair were cut from the wither region, close to the skin of the animal; 10 ml of blood were taken from the jugular vein. Faecal samples were collected by rectal inspection to evaluate the presence of endo-parasites (McMaster method; Smith and Sherman, 2009); skin scrapings were performed to evaluate the presence of ecto-parasites, such as ticks or fleas (direct microscopic examination; Smith and Sherman, 2009).

Continuous variables were compared by non-parametric analysis of variance (t-distribution), whereas frequencies of categorical variables were compared by Pearson's chi-squared test.

RESULTS

Results from Portugal and Italy repetitions are shown in Table 1 and Table 2. As the outcomes were similar in both repetitions, data were pooled for statistical analysis in order to increase the sample size (overall, RH=24; NH=24).

Rectal temperature, respiratory rate and heart rate did not differ between RH and NH goats (Tab. 1). Rectal temperature fell into the normal reference range for goats (38.6-40°C; Smith and Sherman, 2009), whereas respiratory and heart rate considerably exceeded the reference ranges (10-30 breaths/min and 70-90 bpm, respectively; Smith and Sherman, 2009).

	Portugal		Italy		Overall		*Sig.*
	NH	RH	NH	RH	NH	RH	
Rectal temperature (°C)	38.71±0.53	38.76±0.42	39.00±0.35	38.98±0.56	38.83±0.48	38.84±0.48	n.s.
Respiratory rate (min)	57.87±23.85	54.13±21.75	36.44±9.68	32.89±5.58	49.83±22.16	46.17±20.22	n.s.
Heart rate (bpm)	97.73±28.47	113.83±15.26	113.33±28.14	111.56±29.22	103.58±28.78	113.00±20.98	n.s.

Table 1 – Results of the general clinical examinations of NH (normal hair) and RH (rough hair) goats, performed in Portugal, in Italy and in the overall data set, expressed as mean±s.e.. The significance level refers to the overall means (t-distribution).

Nutritional and health condition in RH goats showed a very poor situation compared to NH goats (Tab. 2). Statistical differences were found among RH and NH goats considering too thin animals, both sternum and lumbar area ($p < 0.05$ and $p < 0.001$, respectively) and the presence of abnormal lung sounds ($p < 0.001$).

	Portugal		Italy		Overall		*Sig.*
	NH	RH	NH	RH	NH	RH	
Too thin (sternum)	6.67	40.00	0.00	11.11	4.17	29.17	P<0.01
Too thin (lumbar)	6.67	66.67	0.00	22.22	4.17	50.00	P<0.001
Abnormal mucosae	0.00	13.33	0.00	11.11	0.00	12.50	n.s.
Ruminal sounds	0.00	6.67	0.00	0.00	0.00	4.17	n.s.
Abnormal lung sounds	0.00	53.33	11.11	33.33	4.17	45.83	P<0.001
Abscesses	20.00	46.67	55.56	33.33	33.33	41.67	n.s.

Table 2 – Percentage of NH (normal hair) and RH (rough hair) goats with nutritional and health problems in Portugal, in Italy and in the overall data set. The significance level refers to the overall data (Pearson's chi-squared test).

Low levels of endo-parasites infestation (strongyles and oocysts of *Eimeria*) was found in faecal samples, both in RH and NH goats, although no statistical differences were found.

	Portugal		Italy		Overall		*Sig.*
	NH	RH	NH	RH	NH	RH	
Strongyles	64.28 ±137.88	22.72 ±41,01	156.25 ±204.31	184.44 ±241.75	97.73 ±166.53	95.50 ±179.74	0.763
Oocysts of *Eimeria*	1333.33 ±3526.26	54.13 ±21.75	1075.00 ±2206.10	400.00 ±370,81	1243.48 ±3078.53	1150.00 ±3296.41	0.792

Table 3 – Results of endo-parasites infestation (epg) of NH (normal hair) and RH (rough hair) goats, performed in Portugal, in Italy and in the overall data set, expressed as mean±SE, among NH and RH. The significance level refers to the overall means (t-distribution).

The presence of ecto-parasites was never recorded in any of the groups.

Blood serum and hair analysis are still on going and the results for mineral levels are therefore not available yet.

DISCUSSION

Our results show that RH goats have a significantly poorer body condition compared to NH. Both the palpation of the sternum area and of the lumbar area confirms the presence of a high proportion of too thin RH goats. This result suggests that these animals are experiencing nutritional problems that may be due, for example, to a chronic disease, high parasitic load or to a mineral deficiency. It is known that mineral deficiencies may lead to a consistent loss of weight in goats (Lengarite et al., 2012; Veit et al., 1993). However, at the moment, blood serum and hair samples analysis for the assessment of possible mineral deficiencies are still running, so we cannot confirm the role of these deficiencies in determining body conditions.

The poor body condition of RH goats might also be related to their general health condition. The higher prevalence of abnormal lung sounds in these animals, associated with normal rectal temperature, is probably a result of a chronic respiratory disease, supporting the idea from Berg et al. (2009) whereby the hair coat condition may reflect hidden pathologies.

According to our study and partly against expectations (Sarkar et al., 2010), the hair coat conditions did not result from the presence of parasitic infestation. However, we have to take into account the fact that the research was carried out in intensive dairy farms, with no access to pasture, and this may explain the very low level of parasite infestation that was recorded both in Portugal and in

Italy. This does not allow us to exclude that parasites can affect hair condition, but it allows saying that parasites are certainly not the only cause of a rough hair condition.

CONCLUSIONS

Nutritional and health status in goats showing rough hair coat are considerably worse than those of goats with shiny hair coat, therefore our results support the idea that hair coat condition can be a valid and feasible indicator for on-farm evaluation of goat welfare. The use of this indicator can be very advantageous, as the assessment of hair coat condition is quick, practical and feasible to be applied on-farm. Further studies are needed to define correctly and uniquely this indicator, in order to make it repeatable and reliable.

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General conclusions

The studies presented in this thesis deal with different critical points, concerning animal welfare. This issue shows several complexities into the proper approach. Concerns and interests towards animal welfare are constantly growing, so it appears mandatory to broaden the knowledge, covering and filling as many gaps as possible.

Studies presented in Chapter 1 and 2 show specific adaptations to already developed and validated on-farm welfare assessment protocols on cattle.

In Chapter 1, we found that human-animal relationship tests are not consistent throughout the year, in traditional alpine husbandry systems, as important management changes may affect the quality and the quantity of encounters with humans. So, for certification purposes, welfare assessments should be performed during the most representative period (e.g. before the summer grazing period, reflecting the condition during the indoor period and the situation in which cows live during most of the year).

In Chapter 2, results of the study presented suggest that the effect of the breed significantly affect the presence of health problems and physical malformations in dairy cows housed in tie-stalls in alpine traditional husbandry systems. This finding leads to the need of ensuring or enhancing animal welfare in breeding programs, preventing the loss of biological and genetic diversity of local breeds, which have the capacity to adapt to specific environmental conditions.

An important consideration to do about the chapters above is that protocols may be adjusted to different contexts and environments. We presented studies considering the Italian context, where traditional husbandry systems are still widely represented and local breeds are existing and strongly defended to ensure the biodiversity of farmed animals and typical products. This reality is part of the history of Italy, so it deserves to be properly evaluated, criticizing weak aspects, but enhancing positive items. This approach may be applied to other countries, as a welfare approach cannot be a static evaluation. Further studies are required in order to make the welfare assessment more accurate.

On the contrary, in Chapter 3, 4 and 5, many efforts still need to be realized, as farm species, such as goats still lack of protocols to guarantee an adequate level of welfare. The review that we presented in Chapter 3 may be a valid starting point to approach this issue, as a huge amount of work and studies need to be completed or again adjusted. Goats are ruminants, as well as cows, but they differ in their behaviour and biology, so well-target studies need to focus on goats and not only be adapted from previous studies conducted on cattle.

Chapter 4 confirms this statement as human-animal relationship tests set up for cattle seem feasible in goats and are able to detect differences depending on farm size and, consequently, on management practices. Compared to cows, goats seem generally more confident with man, so adjustment are require in order to gather more representative information about this important issue.

Chapter 5 shows a new indicator to be collected on goats. Although studies had been never carried out on hair coat condition in goats, farmers frequently observe the hair condition of their animals to gather information about the health status. The study presented confirms the validity of this indicator as nutritional and health condition in goats showing rough hair coat are considerably worse than those of goats with shiny hair coat. The use of this indicator can be very advantageous, as the assessment of hair coat condition is quick, practical and feasible to be applied on-farm.

In conclusion, animal welfare is still a field to be explored, many efforts are required in order to improve the understanding of the complexity of this topic.

Acknowledgements

Foremost, I would like to express my sincere gratitude to all the people that I met during these years, full of personal and professional satisfactions. I will not make the list of names: if you are reading, it is because I am addressing to you, otherwise I hope I will have the possibility to tell you!

I also think that you will forgive me if the rest the acknowledgments will be in Italian and maybe few lines in Portuguese!

Come al solito, come per tutte le precedenti tesi, i miei primi ringraziamenti sono rivolti alla mia famiglia: mamma, papà e nonna! Che siete speciali, unici, meravigliosi, lo sapete già. Non credo che mai ci saranno parole per ringraziarvi per avermi sostenuto fino a questo punto, dandomi la forza, le possibilità e l’appoggio per realizzare il mio sogno, che sapete, era proprio quello che avevo da bambina. E spero di essere riuscita a rendervi orgogliosa e magari felici… Vi adoro!

Ringrazio Demos perché ci siamo incontrati proprio quando iniziava il mio percorso universitario e siamo ancora qua insieme, più uniti e forti di prima a sostenerci ogni giorno davanti a mille difficoltà, ma altrettante soddisfazioni e gioie. Perdonami per aver passato quasi tutte le sere e i weekend a lavorare negli ultimi mesi, so che sei comprensivo, ma prometto che non capiterà più! Master per il momento non ho intenzione di farne, con le tesi dovrei aver terminato!

Ringrazio la professoressa Mattiello, o meglio Silvana, per la pazienza dimostrata ogni giorno nell’aiutarmi a crescere e spronarmi a migliorare. Se questi anni sono stati così intensi, lo devo davvero a lei! A volte anche troppo intensi!

E tambem gostaria de agradecer ao professor Stilwell para os seus sempre uteis comentarios. Estou aqui à espera da apresentação do próximo livro, lembra-se de convidar-me!

Ringrazio le mie colleghe tutte (e anche i pochi colleghi!), ognuna di loro ha reso speciale un momento di questi anni e so di essere davvero fortunata ad avervi incontrate! Ringrazio la mia dirimpettaia di scrivania per aver trovato la colonna sonora alla scrittura della mia tesi (in questo caso ringrazio anche Neffa per aver scritto “Molto calmo”!!!); ringrazio tutti per i pranzi, le cene, i convegni, le uscite in azienda (sì, anche quelle alle 5 del mattino col freddo, il gelo e poche ore di sonno alle spalle!), i caffè (soprattutto quelli offerti!)… non potete immaginare quanto il vostro calore e allegria mi siano mancati in Portogallo!

Ringrazio tutti i miei amici, per i momenti meravigliosi passati insieme e che mi hanno sempre permesso di svagarmi e recuperare le energie per rituffarmi con entusiasmo nel lavoro. In realtà, a volte a non vedervi, le energie le avrei anche risparmiate, però ne è sempre valsa la pena! Un immenso grazie a Andy, Gigi, Marty, Mav, Paola, Fabri, Fedina, Fede, Andriù, Jac, Ros, Ross, Gigi di M, Finni!

Gostaria de agradecer as colegas portuguesas, Inês e Ana: foi uma sorte imensa encontrar vocês!

Agradeço muito Lisboa, uma cidade mágica que ofereceu-me um momento único da minha vida: tenho saudades da luz da cidade ao pôr do sol, do som das ondas do oceano (mas não da água fria!), das noites nos bairros, da musica pimba, do Santo Antonio e o cheiro das sardinhas, das imperiais, do chouriço, dos pasteis de nata, dos caracois, dos jogos de futebol em todas as horas e de todos os amigos que encontrei!

E per ultimo, ma solo perché non può leggere, ringrazio Tonino! Lo so “è solo un cane”, ma è un cane che è arrivato quando doveva arrivare, che mi ha cambiato e stravolto la vita, che quando sono giù e ho solo bisogno di sfogarmi, è lì… perché non sa quello che dico, ma capisce come sto…