



## Monitoring the on-farm welfare of sheep and goats

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### ABSTRACT

Schemes for on-farm welfare assessment in sheep and goats are not yet available. Factors responsible for this lack of availability are discussed in the first part of this review. Requisites for reliable methods of welfare assessment to be used in sheep and goat farms are discussed, taking into account the peculiarities of the small ruminant production systems in terms of flock management and farm location. Some housing parameters related to structures, design and micro-environment are reviewed and could be included in schemes of welfare assessment on farm. Human-animal interaction, health status of the animals in terms of body condition scoring, skin and hair conditions, lameness and injuries, and management practices in relation to cleanliness, animal handling and moving, milking procedures and abnormal behaviours, are proposed as potential animal-based indicators. When available, validity, reliability and feasibility of the proposed parameters are discussed. The voluntary adherence to welfare standards in Sardinia and the application of a scientifically validated protocol in Basilicata are reported as examples of practical experiences.

*Key words:* Animal welfare, Sheep, Goats, Monitoring system.

### RIASSUNTO

#### MONITORAGGIO DEL BENESSERE DEGLI OVI-CAPRINI A LIVELLO AZIENDALE

*In apertura di questa rassegna sono brevemente discussi i motivi dello scarso sviluppo dei sistemi di monitoraggio del benessere degli ovi-caprini e le circostanze che impongono di colmare il divario esistente in questo campo tra i piccoli ruminanti ed altre specie da reddito. Vengono inoltre suggeriti i requisiti che*

*possibili modelli di valutazione del benessere dei piccoli ruminanti a livello aziendale dovrebbero avere, alla luce delle specificità dei sistemi di allevamento degli ovi-caprini in termini di management del gregge e dislocazione geografica degli allevamenti. Gli autori descrivono i parametri relativi agli elementi strutturali, dimensionali e micro-ambientali dei ricoveri zootecnici per ovi-caprini candidati ad entrare in un modello di valutazione del benessere a livello aziendale. Ai fini del monitoraggio del benessere a livello aziendale vengono anche discussi, alla luce dei requisiti di validità, affidabilità ed applicabilità, alcuni parametri potenziali indicatori delle interazioni uomo-animale, dello stato di salute degli animali (body condition score, condizioni di vello e tegumento, presenza di lesioni e traumi) e della conduzione aziendale (grado di pulizia, movimentazione e maneggiamento degli animali, organizzazione delle operazioni di mungitura, presenza di anomalie comportamentali nell'adulto e nel redo). Infine vengono riportate alcune esperienze pratiche riguardanti gli standard di benessere adottati per gli ovini nella regione Sardegna e l'applicazione di uno schema di monitoraggio del benessere delle pecore derivato dall'ANI (Animal Needs Index) 35 L in Basilicata.*

Parole chiave: *Benessere animale, Ovini, Caprini, Modello di valutazione.*

## Introduction

The development of a monitoring system is needed for ranking the welfare state of small ruminants at farm level. The assessment of welfare at farm level could be used to quantify the impact of different husbandry conditions on animals, but it could be also used for legislative requirements, as a certification system and as an advisory and management tool by farmers (Main *et al.*, 2003). The assessment of welfare in sheep and goat farms is also needed to increase quality and hygienic standards of food production. In addition, consumers demanding high quality food also expect animal products to be obtained and processed with greater respect for the welfare of the animals. The development of on-farm welfare monitoring systems to be applied is contained in an EU research program entitled "Welfare Quality" (<http://www.welfarequality.net/>) and in the COST action 846: "Measuring and monitoring farm animal welfare" (<http://www.cost846.unina.it>). However, in both programs small ruminants are not included. Only few items for monitoring sheep and goat welfare are contained in the Code of Recommendation for the Welfare of Livestock (Department for

Environment, Food and Rural Affairs, 2003) that is applied in the United Kingdom. Poor scientific production on small ruminant welfare assessment could be ascribed to the fact that sheep and goats are known to have a high degree of adaptability and are still predominantly raised in extensive production systems. More recently, intensive production systems for small ruminant species have spread through the Northern countries of the Mediterranean basin and specialised dairy flocks have increased in size. In addition, goat and sheep are often cared for by shepherds who have no specific stockmanship skills and do not possess the appropriate abilities, knowledge and professional competence to be aware of the welfare standards relevant to the animals. Thus, the present review discusses several issues that may be useful to develop on-farm welfare monitoring systems for small ruminants.

## Potential indicators of sheep and goat welfare at farm level

The science-based assessment of small ruminant welfare should be the integration of both animal-based indicators and resource-based parameters. On-farm welfare

assessment starts from the choice of proper welfare indicators: they should be simple to apply, easy to interpret and applicable (Farm Animal Welfare Council, 2005). In addition, the indicators must be valid, which means that they should be important in terms of animal welfare, and reliable, which indicates the tendency to give the same results by two or more observers.

### *Stockmanship*

Human-animal interactions play a principal role in sustaining the welfare and production of domestic animals (Hemsworth, 2003). The quality of interactions with stock-people is especially relevant to small ruminants because they are quite afraid of people and little accustomed to handling, especially in meat and extensively reared breeds. A number of studies have demonstrated that human-animal relationship has an impact on sheep and goat welfare, thus stockmanship can be rightfully proposed as an animal based indicator of sheep and goat welfare at farm level.

The most significant influence of the shepherd on the flock is during the milking procedures and the artificial rearing of lambs and kids. In goats, a reduction in milk yield and milk let down is associated with negative interaction and fear of humans (Lyons, 1989). Lambs subjected to bottle feeding and receiving gentle handling exhibit less negative effects by the presence of the shepherd when separated from the flock (Boivin *et al.*, 1997). Gentle treatment can be properly used in artificial rearing programs of lambs in order to sustain lamb immune function and reduce the risk of disease (Caroprese *et al.*, 2006). Evidence also exists that gentleness reduces plasma cortisol response of lambs to handling, and this seems to have positive effects on slaughter stress and, consequently, on lamb meat pH and tenderness (Napolitano *et al.*, 2006).

Behavioural tests aiming to assess the quality of the human-animal relationship in large ruminants are avoidance distance from the stockman in the home pen, avoidance distance at the manger and approach behaviour (Waiblinger *et al.*, 2003). Reactions of animals to humans can be easily evaluated by measuring avoidance distances in small ruminants, too.

Parameters such as capture time for milking and animal behaviour in the waiting area and in the milk parlour (kicking, defecation and urination during milking), easily detectable in field conditions, could represent other reliable indexes to evaluate animal welfare.

### *Health*

The health status of the flock could be evaluated by scoring the body condition (BCS), checking skin and hair conditions, and detecting lameness and injuries. BCS estimates condition of muscling and fat development. BCS is measured in a five-point scale (from 1 to 5); scores of 4 or higher indicate fatness or obesity, while score lower than 2 are detected in thin and emaciated animals. Low BCS depends on an intense mobilisation of body fat reserve (and nitrogen reserve at a lesser extent), due to reduced energy intake and/or increased energy output, which mainly occur under high heat load situations (Sevi *et al.*, 2001a, 2002) and during suckling, and early stage of lactation (Sevi *et al.*, 2001a; Albenzio *et al.*, 2003). Vice-versa, high BCS is sign of overfeeding or excessive confinement of animals. In goats under extensive rearing conditions, the body condition score is correlated with milk yield (Cabiddu *et al.*, 1999). Thus, apart from sickness, deviations from average body condition scores depend on inadequate feeding management in terms of excessive or limited energy content of the diet and of unbalance between nutrient in-

take and requirements of the animal on a given physiological stage.

Monitoring the health of sheep and goat flocks cannot disregard the state of preservation of forage and concentrates (by paying particular attention to possible mould contamination) as well as the dryness and air change of storage buildings.

Grazing sheep are exposed to endo and ecto-parasitic diseases, which leads to a reduction of feeding efficiency, growth rate, and production performances together with hair and skin lesions (Otranto and Lia, 2006). Steele (1996) reported that goats are very agile but can suffer poor feet including foot rot. Foot rot in all its forms is generally the most important condition causing lameness also in sheep. Lameness in sheep and goats may be an indicator of hard environmental terrain, wetness, untrimmed hoofs, penetrating injuries, trauma, fracture, and inflammation of anatomical structures and glands (Mohammed *et al.*, 1996). Lameness in sheep and goats contributes to pregnancy toxæmia, and to neonatal diseases, and significantly reduces the reproductive capacity of small ruminants (Eze, 2002).

### *Management*

Shepherds have to properly inspect the flock within their routine management practices. In order to sustain health status of the flock the shepherd should clean the parts of the accommodation with which the sheep come into contact, and the boxes and pens should be disinfected every time they have been emptied and before new animals are brought in (Recommendation Concerning Sheep, Council of Europe, 1992). As demonstrated in dairy cattle (Blom, 1983; Blowey, 1993; Busato *et al.*, 2000), dirtiness can predispose animals to injury and lameness. Similarly, the presence of dirty sides, and hind limbs in small ruminants may indicate inadequate management practices

and poor care of animals by stockmen.

Some of the management practices adopted by the shepherds can be stressful for livestock: group exchanges and relocations are routinely used to obtain uniform groups of sheep, but can result in transient stress, altered cell-mediated immune responses and increased frequency of aggressive behaviours (Sevi *et al.*, 2001c). In small ruminants aggressive behaviours are abnormal behaviours often connected to stressful management procedures (Mellor *et al.*, 2000). In sheep, wool biting and slat chewing are regarded as abnormal oral behaviours (Cooper *et al.*, 1994; Cooper and Jackson, 1996), and their detection could be considered as an indicator of stressful management procedures.

Good milking practices should take into account dairy hygiene, good functioning of milking machines, careful handling of animals, and examination of foremilk (Department for Environment, Food and Rural Affairs, 2003). Cleanness of the udder, of the milking parlour, of the milking-machine, and of milkers' hands and equipment can be used to evaluate the level of welfare in dairy sheep and goats, because they have been proven to be the main source of mastitis infections (Albenzio *et al.*, 2002, 2003). In addition, the vacuum level and pulsation rate of the milking machine should be considered in an on-farm monitoring system: both high vacuum levels (> 40 kPa) and high pulsation rate and/or ratio have to be regarded as inadequate to sustain dairy sheep and goat welfare, because they are directly related to somatic cell count (SCC) (Pazzona and Murgia, 1993; Sinapis and Vlachos, 1999; Pazzona *et al.*, 2003).

### *Housing*

Sheep and goat houses are often inadequate in terms of design, materials and size. In addition, poor control of ambient hygiene

is often observed in sheep and goat houses. The most reliable criteria to monitor the welfare of small ruminants with respect to rearing structures can be space allowance, shelters from climatic extremes, and lighting.

A number of experiments provide recommendations regarding values of dimensional and micro-environment parameters to use for assuring satisfactory welfare levels in small ruminants. A stocking density of 2 m<sup>2</sup>/animal has been recommended to sustain both production performances and health of lactating ewes (Sevi *et al.*, 1999). The treatment of litter with bentonite (0.5 kg/m<sup>2</sup> of litter) can be used to control the concentration of microorganisms in the air and milk under conditions of high stocking density (Sevi *et al.*, 2001d). A volume allocation of 7 m<sup>3</sup>/animal is also required for health and good efficiency of production of the lactating ewe (Sevi *et al.*, 2001b).

Adequate ventilation rates and lighting in sheep and goat houses are recommended in the Code of Recommendation for the Welfare of Livestock that is applied in the United Kingdom. A mean ventilation rate of about 65 m<sup>3</sup>/h per ewe in summer and of 45 m<sup>3</sup>/h per ewe is required in sheep houses to sustain the performance and the welfare of lactating ewes (Sevi *et al.*, 2002, 2003). Very low (10 lux) and high (1000 lux) light intensities lead to increased frequency of abnormal behaviours in Comisana lambs (Casamassima *et al.*, 1993).

### *Environment*

The areas where sheep and goat breeding is more diffused are characterised by hot summers so a major environmental threat to animal welfare is heat stress if flocks are not suitably sheltered against high air temperatures and solar radiation. Evidence exists that lactating ewes suffer from daily mean air temperatures exceeding 30°C and THI (Temperature Humid-

ity Index) near or over 80, and even from ambient temperatures peaking up to 35°C for few hours during the day (Sevi *et al.*, 2001a). When such conditions occur, sheep display increased breath rate and rectal temperature and decreased cell-mediated immune reactivity. Hence, in hot climates sheep should have shaded areas to protect themselves from solar radiation as well as water available at any time. Also shearing can help animals to face high air temperatures during the summer season (Pennisi *et al.*, 2004). There are a lot of objective measures that can be used as indicators of pending high heat load situations. Some of them can be taken from animals (rectal and skin temperature, breath rate); these measures are direct indicators of current or failed thermoregulation effort, but they take a long time to be collected in terms of animals to be sampled and of time required for taking reliable measures. As an alternative, other measures can be taken from the environment (air temperatures, relative humidity, solar radiation). A number of portable instruments can be used to record instantaneous air temperatures and relative humidity; however, heat stress in animals can only be indirectly inferred through these measures. In addition, instantaneous recording of air temperature and relative humidity does not make it possible to identify heat waves (i.e., relatively long and uninterrupted periods of very high air temperatures) that sheep and goats can be exposed to with severe impact on their welfare. Electric thermo-hygrographs, computerized thermo-hygrometers, and meteorological stations can be used for continuous monitoring of air temperature and relative humidity in sheep and goat houses and in paddocks. At the moment, the temperature-humidity index could be considered a good indicator of thermal stress in farm animals (Silanikove, 2000).

Some proposed indicators to monitor on-farm sheep and goat welfare, in terms of human-animal relationship, animal health, management practices, and housing conditions are reported in Table 1.

### Strategies to improve welfare in sheep flocks: the Sardinian experience

In 2006 the Sardinia Government, within a rural development plan (Measure F),

Table 1. Candidate indicators for on-farm welfare assessment in sheep and goats.

Parameter	Species	Standing for	References
Avoidance distance	Dairy Cows	Human-animal relationship	Waiblinger <i>et al.</i> , 2003
Capture time for milking			Foddis <i>et al.</i> , 2005
Kicking, defecation and urination during milking			
Body Condition Score	Sheep	Health Status	Sevi <i>et al.</i> , 2001a, 2002; Albenzio <i>et al.</i> , 2003
	Goats		Cabiddu <i>et al.</i> , 1999
Skin and Hair lesions	Sheep		Otranto and Lia, 2006
Lameness	Sheep Goats		Mohammed <i>et al.</i> , 1996; Eze, 2002
Abnormal behaviour	Sheep	Management Practices	Sevi <i>et al.</i> , 2001c; Cooper <i>et al.</i> , 1994; Cooper and Jackson, 1996
Animal Dirtiness (sides, hind limb, udder)	Dairy Cows		Main <i>et al.</i> , 2004
Milking Machine Parameters (Vacuum Level and Pulsation Rate)	Sheep Goats		Pazzona and Murgia, 1993; Sinapis and Vlachos, 1999; Pazzona <i>et al.</i> , 2003; Murgia and Pazzona, 2001
Cleanness of milking parlour, of milking-machine, and of milkers' hands	Sheep		Albenzio <i>et al.</i> , 2002, 2003
Stocking density	Sheep	Housing	Sevi <i>et al.</i> , 1999, 2001d
Air quality	Sheep		
Lighting	Sheep		Casamassima <i>et al.</i> , 1993
Air temperature and relative humidity	Sheep	Environment	Sevi <i>et al.</i> , 2001a, 2001b, 2002, 2003a, 2003b; Curtis, 1983

undertook measures to improve the welfare conditions of small ruminants. This topic has great impact in Sardinia because its 12,500 sheep and goat farms, which breed more than 3.5 million heads, represent the most important animal husbandry activity on the Island.

Since lactation is the preponderant physiological phase (9-10 months/year) in the productive cycle, the Regional Action has focused on the improvement of welfare under milking conditions. In particular, the welfare regional plane decided to use Somatic Cells Content (SCC) as an animal welfare indicator, aiming at achieving a SCC in milk lower than 1,000,000/ml in 5 years. This was based on the fact that SCC in milk is negatively related to production level, quality and cheese making properties of milk (Sevi *et al.*, 1999; Pirisi *et al.*, 2000; Albenzio *et al.*, 2004; Pulina *et al.*, 2004, 2005).

The regional plan has focused on the following management operations which can influence SCC in milk: milking, litter management, mastitis detection and animal-human interaction.

In particular, farmers who agree with the program of animal welfare improvement must respect the following rules for 5 years (Foddìs *et al.*, 2005):

- i) to arrange small enclosures near the milking parlour to allow access of small groups of animals to milking. This condition reduces over-crowding in the waiting area and dominance actions in the flock;
- ii) to check vacuum and pulsation frequency, to perform regular maintenance of milking machine, certified by specialised firms, at least twice a year;
- iii) to reduce the stress in primiparous ewes by training them to the milking parlour environment, noise, milking

machine contact and restraint by the automatic capture system; this training must start at least 15 days before lambing and must continue during the suckling of lambs (about 30 days). Primiparous ewes must be separated from pluriparous ones during the first month of milking, in order to reduce competition stress;

- iv) to send milk samples for periodical milk quality analysis, especially SCC, by an authorised laboratory;
- v) to monitor milking animals, by using the California Mastitis test (CMT) or by measuring the electric conductivity of milk, in order to detect and separate animals with a high probability of having mastitis infection. In order to avoid the spread of infection within the flock, these unhealthy animals should be milked last and the milking machine should be accurately cleaned;
- vi) to improve the rest area conditions, by adding appropriate material to the litter every week, while litter should be completely removed, followed by disinfection and disinfestation of the area, at least 3 times per year;
- vii) to take lessons (10 hours/year) in educational courses about animal welfare, since animal welfare is mainly influenced by the human factor.

All farmers that follow the above rules will receive about 20 euros/head/year, which represents a reward for the higher welfare level achieved with greater work, better animal care and higher production costs.

In order to make sure that farmers follow all required actions, every year each farmer will have to provide the following documents:

- i) certificate of adequate functioning of milking-machine released by spe-

- cialised workers (performed twice a year);
- ii) certificate of milk analysis released by the laboratory, which make is possible to verify if the trend of SCC has been decreasing over time;
- iii) certificate of attendance for the educational courses taken on animal welfare.

On the basis of the results of the above listed certificates, a random sample of at least 5% of the farms will be controlled *in situ* by regional technicians. The higher the number of farms showing negative results, the higher the percentage of farms sampled. In each sampled farm, it will be determined if all husbandry techniques required by the Regional plane had been respected. The farms that do not respect the required rules will have to pay a variable penalty that may be as high as 100% of the expected reward.

### **Application of a scientifically validated monitoring scheme in Basilicata**

Due to a lack of welfare monitoring schemes for small ruminants a protocol scientifically valid for cattle, the ANI 35L 2000, was adapted to sheep. As for the Animal Needs Index proposed by Bartussek *et al.*, (2000), this protocol relies on a graded point system that allows the assessment of five aspects of the housing relevant to animal welfare. These aspects are scored through 5 corresponding assessment sheets, namely: Locomotion (Sheet 1), Social interaction (Sheet 2), Flooring (Sheet 3), Environment (Sheet 4) and Stockmanship (Sheet 5), as described by Napolitano *et al.* (2008). Sheet 5 also included the following animal-based variables recorded on at least 20% of lactating animals: integument alterations, animal dirtiness, hoof overgrowth, lameness and lesions, which

were scored on the basis of their prevalence (number of affected animals/numbers of observed animals), longevity (years) and mutilations (de-horning, caudotomy, etc.). The final score ranges from 81 to -9.5 and the higher the score the better the sheep welfare. Two main problems are associated with the ANI protocol: (a) it mostly relies on design criteria with a lack of animal based variables; (b) it allows compensation between poor and good conditions. However, this index, at least in cattle, has proven to be valid (Ofner *et al.*, 2003), reliable (Amon *et al.*, 2001) and to have some common criteria with consumer perception of animal welfare (Napolitano *et al.*, 2007).

In order to evaluate the inter-observer reliability of the scheme two trained observers visited 13 sheep farms located at an average altitude of 844 m above sea level. The mean number of heads per farm was 350 and Merinizzata Italiana the most common breed. The average milk yield was 80 kg, including the amount ingested by the lambs. Observations were conducted on lactating animals and on their home pen. For each sheet and each qualitative parameter inter-observer reliability was computed using the Spearman coefficient of correlation ( $r_s$ ).

The mean time needed to perform the assessment of welfare was 49 min per farm. No sophisticated equipment was necessary in both time consuming and economical terms. In Table 2 the animal related variables monitored in this study are shown. The mean total score of the sheep farms ( $50.25 \pm 1.13$ ) was well above the central point of the scale ( $81 - 9.5/2 = 35.75$ ), which indicated an overall satisfactory level of welfare. The application of the scheme showed that the most critical aspects of sheep farms were the low indoor and outdoor space allowance and the lack of an outdoor paddock in 46% of the farms. However, these aspects were compensated for



Table 2. Mean (+ SE) of some animal related variables.

Longevity (years)	Integument alterations (%)*	Hoof overgrowth (%)*	Lameness (%)*	Lesions (%)*	Dirtyness (%)*
8.08 ± 0.54	9.43 ± 2.21	1.65 ± 0.97	3.75 ± 1.2	1.03 ± 0.3	30.06 ± 5.33

\*Percentage of affected animals.

by frequent access to the pasture, which was not allowed only in very bad weather conditions. In addition, pasture was steep in most of the cases, thus allowing good physical exercise for the animals. As to animal-based parameters, the prominent aspect to be improved was dirtiness, as it affected the highest percentage of animals. This aspect is obviously dependent on to the low space allowance offered to the ewes in the barn and also related to the fact that the animals were observed in the early morning, before access to pasture.

Inter-observer reliability as assessed by Spearman correlation coefficient was significant for total score ( $P < 0.001$ ), all sheets ( $P < 0.01$ ) and all animal based parameters ( $P < 0.05$ ), apart from lesions ( $P < 0.10$ ). However, the level of statistical significance of the correlation says little about the degree of reliability, as significance also depends on the sample size, whereas the value of the correlation coefficients is much more informative on the strength of the association. Martin and Bateson (2007) suggest that, although acceptability of coefficients depends on several factors, a satisfactory threshold can be considered 0.7. In this study the  $r_s$  of total score and all sheets exceeded this value, whereas only 3 (hoof overgrowth, lameness and dirtiness) out of 5 animal based parameters showed coefficients higher than 0.7, thus indicating that more training was needed for the assessment of integument alterations and lesions in order to obtain reliable measures.

So, the present monitoring protocol proved to be feasible and reliable, although more studies are needed to test the scheme on a larger sample size and assess its validity.

### Conclusions

Measures suggested and schemes discussed in the present review are a first attempt to develop an on-farm monitoring system for small ruminants, so they can be considered the starting and not the conclusive point for opening a scientific debate on the topic. In particular, it is not excluded that instead of applying concepts validated in other farm species, a specific model for the evaluation of on-farm welfare assessment in small ruminant could be developed. The development of a monitoring system for on-farm welfare assessment of sheep and goats can be of great importance: firstly, because it will contribute to improve the quality standards of small ruminant management; secondly, because most of sheep and goat products are officially recognized in the EU regulation with a protected designation, thus the inclusion of a welfare monitoring system into the specifications of such products could further improve their market value. Further studies are needed on the impact of management and environmental factors on small ruminant welfare in order to find additional and feasible measures of proven validity and reliability to be used for monitoring protocols in sheep and goat farms.

## REFERENCES

- Albenzio, M., Caroprese, M., Santillo, A., Marino, R., Taibi, L., Sevi, A., 2004. Effects of somatic cell count and stage of lactation on the plasmin activity and cheesemaking properties of ewe milk. *J. Dairy Sci.* 87:533-542.
- Albenzio, M., Taibi, L., Caroprese, M., De Rosa, G., Muscio, A., Sevi A., 2003. Immune response, udder health and productive traits of machine milked and suckling ewes. *Small Ruminant Res.* 48:189-200.
- Albenzio, M., Taibi, L., Muscio, A., Sevi, A., 2002. Prevalence and etiology of subclinical mastitis in intensively managed flocks and related changes in the yield and quality of ewe milk. *Small Ruminant Res.* 43:219-226.
- Amon, T., Amon, B., Ofner, E., Boxberger, J., 2001. Precision of assessment of animal welfare by the "TGI 35 L" Australian Needs Index. *Acta Agric. Scand. A* 30:114-117.
- Bartussek, H., Leeb, C.H., Held, S., 2000. Animal needs index for cattle. ANI 35L/2000 – cattle. Federal Research Institute for Agriculture in Alpine Regions BAL Gumpenstein. Home page address: [www.bal.bmlf.gv.at/index.php](http://www.bal.bmlf.gv.at/index.php)
- Blom, J., 1983. Traumatic injuries and foot diseases as related to housing systems. In: S. Baxter, M. Baxter and J. MacCormick (eds.) *Farm animal housing and welfare*. Martinus Publ., Lancaster, UK, pp 216-223.
- Blowey, R., 1993. *Cattle lameness and hoofcare: An illustrated guide*. Farming Press, Ipswich, UK.
- Boivin, X., Nowak, R., Despres, G., Tournadre, H., Le Neindre, P., 1997. Discrimination between shepherds by lambs reared under artificial conditions. *J. Anim. Sci.* 75:2892-2898.
- Busato, A., Trachsel, P., Blum, J., 2000. Frequency of traumatic cow injuries in relation to housing systems in Swiss organic dairy herds. *J. Vet. Med. A* 47:221-229.
- Cabiddu, A., Branca, A., Decandia, M., Pes, A., Santucci, P.M., Masoero, F., Calamari, L., 1999. Relationship between body condition score, metabolic profile, milk yield and milk composition in goats browsing a Mediterranean shrubland. *Livest. Prod. Sci.* 61:267-273.
- Caroprese, M., Napolitano, F., Albenzio, M., Annicchiarico, G., Muscio, A., Sevi, A., 2006. Influence of gentling on lamb immune response and human-lamb interactions. *Appl. Anim. Behav. Sci.* 99:118-131.
- Casamassima, D., Sevi, A., Montemurro, O., 1993. Effetto dell'intensità luminosa sulle prestazioni produttive e sul comportamento di agnelle di razza Comisana allevate intensivamente. *Zoot. Nutr. Anim.* 19:251-259.
- Cooper, J.J., Emmans, G.A., Friggens, N.C., 1994. Effect of diet on behavior of individually penned sheep. *Animal Prod.* 58:441 (abstr.).
- Cooper, J.J., Jackson, R., 1996. A comparison of the feeding behavior of sheep in straw yards and on lasts. *Appl. Anim. Behav. Sci.* 49:99 (abstr.).
- Council of Europe, 1992. Recommendation Concerning Sheep adopted by the standing Committee at its 25<sup>th</sup> Meeting on 6 November 1992. Home page address: [www.coe.int](http://www.coe.int).
- Curtis, S.E., 1983. *Environmental management in animal agriculture*. Iowa State Press, Ames, USA.
- Department for Environment, Food and Rural Affairs, 2003. Code of Recommendation for the Welfare of livestock. Sheep. Home page address: <http://www.defra.gov.uk>
- Eze, C.A., 2002. Lameness and reproductive performance in small ruminants in Nsukka Area of the Enugu State, Nigeria. *Small Ruminant Res.* 44:263-267.
- Farm Animal Welfare Council, 2005. Report on the Welfare Implications of Farm Assurance Schemes. London, UK. Home page address: <http://www.fawc.org.uk>.
- Foddiss, F., Rassu, S.P.G., Pulina, G., 2005. Il benessere degli ovini e dei caprini: una speciale attenzione da parte della Regione Sardegna. In: G. Pulina and D. Brandano (eds.) *Il benessere animale e la qualità delle produzioni nei piccoli ruminanti*. Quaderni dei Georgofili. Avenue Media Publ., Milano-Bologna, Italy, pp 33-46.
- Hemsworth, P.H., 2003. Human-animal interactions

- in livestock production. *Appl. Anim. Behav. Sci.* 81:185-198.
- Lyons, D.M., 1989. Individual differences in temperament of domestic dairy goats and the inhibition of milk ejection. *Appl. Anim. Behav. Sci.* 22:269-282.
- Main, D.C.J., Kent, J.P., Wemesfelder, F., Ofner, E., Tuytens, F.A.M., 2003. Applications for methods of on-farm welfare assessment. *Anim. Welfare* 12:523-528.
- Main, D.C.J., Leeb, C., Whay, H.R., Hovi, M., Webster, J., 2004. Animal based assessment tool for farm animal welfare certification. University of Bristol, United Kingdom. Home page address: <http://www.vetchool.bris.ac.uk/animalwelfare>
- Martin, P., Bateson, P., 2007. *Measuring behaviour*. 3<sup>rd</sup> rev. ed. Cambridge University Press, Cambridge, UK.
- Mellor, D.J., Cook, C.J., Stafford K.J., 2000. Quantifying some responses to pain as a stressor. In: G.P Moberg and J.A. Mench (eds.) *The Biology of Animal stress*. CABI Publishing. CAB International, Wallingford, UK, pp 171-198.
- Mohammed, A., Badau, U.A., Kene, R.O.C., 1996. Lameness in sheep and goats in relation to hoof conditions in Sahel Zone of Nigeria. *Bull. Anim. Health Prod. Afr.* 44:97-100.
- Napolitano, F., Caroprese, M., Girolami, A., Marino, R., Muscio, A., Sevi, A., 2006. Effects of early maternal separation of lambs and rearing with minimal and maximal human contact on meat quality. *Meat Sci.* 72:635-640.
- Napolitano, F., De Rosa, G., Caporale, G., Carlucci, A., Grasso, F., Monteleone, E., 2007. Bridging consumer perception and on-farm assessment of animal welfare. *Anim. Welfare* 16:249-253.
- Napolitano, F., De Rosa, G., Ferrante, V., Barbieri, S., Braghieri, A., 2008. Monitoring the welfare of sheep in conventional and organic farms using an ANI 35 L derived method. pp 36-39 in Proc. 16<sup>th</sup> IFOAM Organic World Congr., Modena, Italy.
- Ofner, E., Amon, T., Lins, M., Amon, B., 2003. Correlations between the results of animal welfare assessments by the TGI 35L Austrian animal needs index and health and behavioural parameters of cattle. *Anim. Welfare* 12:571-578.
- Otranto, D., Lia, R.P., 2006. Diagnostica tradizionale e innovativa delle ectoparassitosi negli ovini e nei caprini. pp 86-91 in Proc. 17<sup>th</sup> Nat. Congr. SIPAOC, Lamezia Terme (CZ), Italy.
- Pazzona, A., Murgia, L., 1993. Effetto del vuoto di mungitura e delle frequenze di pulsazione sulla carica leucocitaria del latte di pecora. *Inform. Agr.* 42(49):43-46.
- Pazzona, A., Murgia, L., Caria, M., 2003. Una mungitura ad hoc anche per la capra. *Inform. Zootec.* 18(50):196-202.
- Pennisi, P., Costa, A., Biondi, L., Avondo, M., Piccione, G., 2004. Influence of the fleece on thermal homeostasis and on body condition in Comisana ewe lambs. *Anim. Res.* 53:13-19.
- Pirisi, A., Piredda, G., Corona, M., Pes, M., Pintus, S., Ledda, A., 2000. Influence of somatic cell count on ewe's milk composition, cheese yield and cheese quality. pp 47-59 in Proc. 6<sup>th</sup> Symp. on Great Lakes Dairy Sheep, Guelph, Ontario, Canada.
- Pulina, G., Nudda, A., Battaccone, G., Cappio-Borlino, A., 2004. Fisiologia della lattazione e qualità del latte negli ovini. *Quaderni dei Georgofili*. Avenue Media Publ., Milano-Bologna, Italy.
- Pulina, G., Nudda, A., Macciotta, N.P.P., Battaccone, G., Fancellu, S., Patta, C., 2005. Non-nutritional strategies to improve lactation persistency in dairy ewes. pp 36-66 in Proc. 11<sup>th</sup> Symp. on Great Lakes Dairy Sheep, Burlington, NY, USA.
- Sevi, A., Albenzio, M., Annicchiarico, G., Caroprese, M., Marino, R., Taibi, L., 2002. Effects of ventilation regimen on the welfare and performance of lactating ewes in summer. *J. Anim. Sci.* 80:2349-2361.
- Sevi, A., Annicchiarico, G., Albenzio, M., Taibi, L., Muscio, A., Dell'Aquila, S., 2001a. Effects of solar radiation and feeding time on behavior, immune response and production of lactating ewes under high ambient temperature. *J. Dairy Sci.* 84:629-640.
- Sevi, A., Massa, S., Annicchiarico, G., Dell'Aquila, S., Muscio, A., 1999. Effect of stocking density on the ewes milk yield, udder health and micro-environment. *J. Dairy Res.* 66:489-499.
- Sevi, A., Taibi, L., Albenzio, M., Annicchiarico, G.,

- Muscio, A., 2001b. Airspace effects on the yield and quality of ewe milk. *J. Dairy Sci.* 84: 2632-2640.
- Sevi, A., Taibi, L., Albenzio, M., Caroprese, M., Marino, R., Muscio, A., 2003. Ventilation effects on air quality and on the yield and quality of ewe milk in winter. *J. Dairy Sci.* 86:3881-3890.
- Sevi, A., Taibi, L., Albenzio, M., Muscio, A., Dell'Aquila, S., Napolitano, F., 2001c. Behavioural, adrenal, immune, and productive responses of lactating ewes to regrouping and relocation. *J. Dairy Sci.* 79:1457-1465.
- Sevi, A., Taibi, L., Muscio, A., Albenzio, M., Dantone, D., Dell'Aquila, S., 2001d. Quality of ewe milk as affected by stocking density and litter treatment with bentonite. *Ital. J. Food Sci.* 13:77-86.
- Silanikove, N., 2000. Effects of heat stress on the welfare of extensively managed domestic ruminants. *Livest. Prod. Sci.* 67:1-18.
- Sinapis, E., Vlachos, I., Barillet, F., Zervas, N.P., 1999. Influence of the vacuum level of the milking machine and zootechnical factors on the somatic cell counts of local Greek goats. *Milking and Milk Production of Dairy Sheep and Goats. Proc. 6<sup>th</sup> Int. Symp. on Milking Small Rumin.*, Athens, Greece, 95:513-518.
- Steele, M., 1996. *Goats. The Tropical Agriculturist CTA.* Macmillan, New York, NY, USA.
- Waiblinger, S., Menke, C., Fölsch, D.W., 2003. Influences on the avoidance and approach behaviour of dairy cows towards humans on 35 farms. *Appl. Anim. Behav. Sci.* 84:23-39.