Animal Welfare and feeding management practices in dairy cattle farms

Monografías do IBADER - Serie Pecuaria

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1 Introduction

Consumers show a growing interest in the quality of products, animal production systems and distribution channels, including issues such as animal welfare, food safety and environmental pollution (Broom, 2010). Those demands refer to a large extent to the upstream farm stages of the so-called supply chain, requiring that those consumer's preferences be incorporated in all stages involved. That is known as traceability "from farm to table" developed by the European Commission under the General Food Law, Regulation (EC) No 178/2002.

On a dairy farm, the environment surrounding the animals, such as facilities design and management practices may determine the status of the animal well-being and cow comfort. Auditing and monitoring programs will reflect the development of a dairy farm over time. Furthermore, a benchmarking process may help identify opportunities to improve within and across farms.

2 Definition of Animal Welfare

Animal welfare is a subjective concept and it can be addressed from different points of view. It is a multi-faceted issue, which implies important scientific, ethical, economic and political dimensions (Lund et al., 2006). The scientific definition of animal welfare address the ability of an animal to cope physiologically, behaviorally, cognitively and emotionally with its physiochemical and social life environment.

Regarding animal welfare in production animals, several authors (Broom, 1996; Duncan, 1996) focused on the state of an animal, including animal's feelings as well as bodily state. Measure of suffer may be difficult, however considering well-being as the result of the adaptation to the environment, it is possible to quantify changes of the animal, including body and behavior, or around the animal, such as environment, facilities and management practices, over time.

3 Implications of the Animal Welfare

Recent crises such as bovine spongiform encephalopathy or BSE, swine fever, foot and mouth disease and avian influenza, have further increased awareness that animal production is more than just an industry. A frequent and worrying question is whether or not animal production has become unsustainable for people, animals and the environment alike. Indeed, a growing ethical concern related to production processes can be identified as a major trend in European food consumer behavior (Steenkamp, 1996).

Understanding how individual animals respond to stress is important in terms of labor safety (Kosaco and Immura, 1999), production (Burrow, 1997), and animal welfare (Grandin, 1997).

Improving animal welfare makes livestock handling safer, reduces labor requirements when using friendly equipment, increases the economic value of cull animals, promotes the use of livestock identification and trace back and increases the value of the products (Grandin, 2000). Ferguson et al. (2001) studied the positive effect of the quality management on the quality product referred to beef palatability. When animals are subjected to severe periods of stress even for short term, such as prior to slaughter, meat became pale, soft and exudative (PSE). However, in a long period of stress it became dark, firm and dry (DFD). The programs implemented by supermarkets and restaurants to inspect farms and slaughter facilities have resulted in great improvements in how animals are managed (Grandin, 2005, 2007).

In biology, the stress is the unspecific answer of the organism facing external demands when animals are subjected to hostile environmental conditions, alteration in climate or management (Gwasdauskas et al, 1975). The animal can adapt, in exchange for a biological cost, or fail to adapt, sick or dying. Only when the animal adapts without requiring a biological cost, it is considered a satisfactory well-being.

The reaction of the animal to stressors depends on the duration and intensity of the stressors as well as the animal's previous experience to the agents, stimulus or conditions, the physiological status and immediate environmental restraints (Grandin, 1997). In general, chronic stress is considered to have a greater potential impact on animal health and welfare than acute stress, because the animals are exposed and reacting to the stressor(s) for longer periods, thereby causing prolonged disruption to homeostasis and related biologic processes (Earley et al., 2010).

3.1. Physiological implications

Stress is commonly defined as a state of real or perceived threat to homeostasis. Maintenance of homeostasis in the presence of aversive stimuli (stressors) requires activation of a complex range of responses involving the endocrine, nervous, and immune systems, collectively known as the stress response (Chrousos and Gold, 1992).

Activation of the stress response initiates a number of behavioral and physiological changes that improve an individual's chance of survival when faced with homeostatic challenges. Behavioral effects of the stress response include increased awareness, improved cognition, euphoria, and enhanced analgesia which will be translated into abnormal behavior, such as stereotypes or rigid behaviors (Chrousos and Gold, 1992; Charmandari et al., 2005). Physiological adaptations include increased cardiovascular tone, respiratory rate, and intermediate metabolism, along with inhibition of general vegetative functions such as feeding, digestion, growth, reproduction, and immunity (Sapolsky et al., 2000; Habid et al., 2001). Due to the wide

array of physiologic and potentially pathogenic effects of the stress response, a number of neuronal and endocrine systems function to tightly regulate this adaptive process.

The stress response consists of a set of physiologic mechanisms designed to return to homeostasis. Two distinct systems link the initial perception of the stressor to this response, that is the sympathetic adrenomedullary (SAM) axis and the hypothalamic–pituitary–adrenocortical (HPA) axis. Both, central and peripheral activation, involves the orchestrated interplay of short-term (acute) behavioral and endocrine responses that prepare animals for an immediate response to environmental adjustment, whereas long-term (chronic) responses involve a substantial adjustment of neuroendocrine, immune, and metabolic responses to the stressor in the brain (Habid et al., 2001; Charmandari et al., 2005).

The General Adaptation Syndrome (GAS) is responsible for develop the adaptation mechanisms for the survival which involves alarm, resistance and exhaustion. The goal of these systems is to maintain homeostasis, to buffer the internal environment from the external environment by the parasympathetic system (Chrousos and Gold, 1992; De Kloet et al., 2005; McEwen, 2012).
The first stage of the GAS is the fight or flight response or acute stress responses which consist on the activation of the sympathetic nervous system to respond a threat. Adrenaline and noradrenaline are released from the medulla of the adrenal glands leading to increased alertness. The release is triggered by acetylcholine from preganglionic sympathetic nerves. These catecholamine hormones facilitate immediate physical reactions by triggering increases in heart rate and breathing, constricting blood vessels and tightening muscles. The body begins to convert stored glycogen into glucose. An abundance of catecholamines at neuroreceptor sites facilitates reliance on spontaneous or intuitive behaviors often related to combat or escape (De Kloet et al., 2005).

The ensuing physiological changes constitute a major part of the acute stress response. The other major player in the acute stress response is the HPA axis. The HPA axis responds to a variety of stressors by synthesizing and releasing four key hormones, namely, corticotrophin-releasing factor or hormone (CRH), arginine-vasopressin (AVP), adrenocorticotrophic hormone (ACTH), and glucocorticoids. Glucocorticoids serve as the final effectors of the HPA axis and are critically involved in modulating the response to any psychologic or physical stressors (Sapolsky et al., 2000).

The alarm phase is many times enough to help overcome stress in the first place. However, if the stressor last for several hours or more, the body enters the resistance phase, the second stage of the GAS. Parasympathetic nervous system returns many physiological functions to normal levels while body focuses resources against the stressor. Blood glucose levels remain high, cortisol and adrenalin continue to circulate at elevated levels, but outward appearance of organism seems normal. If this adaptation process continues for a prolonged period of time without periods of relaxation and rest to counter balance the stress response, sufferers become prone to fatigue, concentration lapses, irritability and lethargy as the effort to sustain arousal slides into negative stress. Stressor continues beyond body's capacity, the glucose levels decrease as the adrenals become depleted and leading to decreased stress tolerance. That is the third stage of the GAS; organism exhausts resources and becomes susceptible to disease and death (De Kloet et al., 2005; McEwen, 2012).

The long-term, chronic stress, usually 24 to 48 hours, may impact on production animals affecting the growth, the immune system production and reproduction (Lay et al., 1992; Buckham Sporer et al., 2008). Those deficiencies can continue after the stimulus from stressor has been diminished or eliminated (MC Donald, 1989).

The stress affect on the growth by decreasing activity from the digestive tract and it promotes hyperglycemia because the rest of the body is not allowed to use the glucose reservoirs and even destroy part of the cells to obtain glucose precursors increasing the lipid and protein catabolism at plasma, muscle and adipose tissue level, mainly (Charmandari et al., 2005).

Effects of stress on immunity (immunosuppression) run via this HPA axis and, in cattle, the synthetic glucocorticoid dexamethasone induces neutrophilia, eosinopenia, lymphopenia, monocytosis and leucocytosis. Glucocorticoids repress the expression of neutrophil adhesion molecules, thereby preventing migration to underlying tissue, leading to neutrophilia and increased mastitis susceptibility (Tempelman et al., 2002). Stress hormones may suppress the production of Tumor Necrosis Factor-alpha by monocytes and this could contribute to the higher susceptibility of cattle to Gram-negative bacterial infections of the udder during stress (Diez-Fraile et al., 2000).

During routine milking, the concentration of plasma cortisol increases physiological in cows. Central inhibition of milk ejection is caused by inhibit of oxytocin from the pituitary gland, and occasionally occurs in cattle production as a result of various stresses, in which decreased levels of oxytocin, and increased levels of β-endorphin, cortisol, ACTH, and catecholamines in blood plasma (Bruckmaier, 2005).

Stressors affect reproductive functions through actions at the hypothalamus as well as impairing pituitary LH release induced by GnRH (Dobson and Smith, 1995). Stress will cause the release of ACTH from the anterior pituitary which, in turn, stimulates release of cortisol and other glucocorticoids from the adrenal cortex. Glucocorticoids inhibit the release of LH. Therefore, if an animal is under stress during a critical period of the oestrus cycle (late proestrus or oestrus) a glucocorticoid induced suppression of LH is likely to either delay or prevents ovulation (Charmandari et al., 2005).

3.2. Productive and economical implications

Stress from metabolic problems may decrease the cow's resistance and compromise immune system function. Disease such as mastitis, lameness, metritis, retained placenta, left displaced abomasum, ketosis, and milk fever and affect production and reproduction performance which is translated into economical losses (Liang, 2013). Diseases occurring early in lactation may lead to delayed conception. Cows may be culled directly or indirectly as a consequence of disease (via low milk production or delayed conception) and some cows die of the diseases being considered. Milk loss, treatment costs, and culling costs were the largest three cost categories identified within those seven diseases (Liang, 2013). The value of dead cow, decreased production and extra labor, and compromised animal welfare, suffering before death or euthanasia (Thomsen and Houe, 2006).

Considering heat stress, annual loss, based on a milk price of $13/cwt, were determined of $897 million for the dairy industry in the United States (St-Pierre et al. 2003). In California dairies, the average dry matter intake (DMI) reduction was calculated of 145 kg/cow/year and a decrease in milk production of about 294 kg/cow/year (St-Pierre et al., 2003). Those dairies also increased 12 days open on average and almost a 1% increase in reproductive culling. Furthermore, implications on reproduction were higher than in milk production on several studies (De Vries, 2004; Flamenbaum and Galon, 2010), e.g. in Florida and Israel the milk production loss was of at most 15% and 7% respectively and a reduction in conception rate of at most 53% and 51% respectively. In addition, embryo loss is 3.7 times more likely in times of heat stress (Thatcher et al., 1986). However, it is estimated that heat load can be reduced from 30 to 50% with well-designed shade and increasing production by 10% (Collier et al., 2006).

The Farm Animal Welfare Committee (FAWC, 2011) reported the impact of economics on farm animal welfare and concluded economics can be used to analyze and appraise policy decisions concerning animal welfare to try to achieve farm animal welfare objectives as effectively and efficiently as possible.

4 Animal Welfare legislation in the UE

The Amsterdam Treaty provides the legislative framework of the EU community under which each member state must abide. A section on animal welfare was appended to the treaty, in order to provide an integrated approach to the development of a community wide protocol on the protection of animals in the EU.

While the treaty provides a broad legislative scope, there is also secondary legislation in the form of Regulations, Directives and Decisions regarding animal welfare in the EU. Other instruments to establish animal welfare objectives include Recommendations and Opinions. Those laws are adopted by the Europe Union (EU), European Council (EC), in conjunction or not with European Parliament or the Commission. The European Food Safety Authority (EFSA) often provides both opinions and recommendations on animal welfare. Recommendations in the EFSA Scientific Opinion on dairy cow welfare were formulated around hazards and these, by definition, relate to the animal's environment and how it is managed.

The EFSA is the risk assessment body regarding food and feed safety. It is independent from government and industry, though it works in close collaboration with national authorities and in open consultation with its stakeholders, including animal protection stakeholders. EFSA provides independent scientific advice and clear communication on existing and emerging risks. It was established by Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002, which lays down the general principles and requirements of food law. The activities of EFSA are carried out by the Panel on Animal Health and Welfare (AHAW). The Panel provides independent scientific advice to the European Commission, European Parliament and Member States on all aspects of animal health and welfare for food producing animals. Its scientific opinions focus on identifying methods to reduce unnecessary pain, distress and suffering for animals and to increase welfare "where possible". They cover the impact of housing, nutrition and feeding, management and genetic selection on the following topics: 1) behavior, fear and pain; 2) metabolic and reproductive disorders; 3) udder problem; 4) leg and locomotion; 5) overall welfare.

Furthermore, the OIE is the intergovernmental organization responsible for improving animal health worldwide. Since it was created, the OIE has played a key role as the sole international reference organization for animal health, directly collaborates with the Veterinary Services of all its Member Countries.

The EC has played a key role in developing standards for Europe, the Five Freedoms, which are noted internationally. These standards are based on both scientific evidence and practical experience and also emphasize the importance of the relationship between animal health and animal welfare. Originally developed in the UK, the Five Freedoms have been adopted as voluntary guidelines that the legislation of all countries should adopt.

The overall framework for EU action on animal welfare is set out in rolling action plans. There was the Community Action Plan on the Protection and Welfare of Animals 2006-2010, and a Second EU Strategy on the Welfare and Protection of Animals 2011-2015 was adopted in December 2011.

There are a significant number of laws and directives regarding animal welfare in the EU. Individual Member States also have their own regulations and directives which enforce the EU-wide legislation. The EU's regulatory framework for animal husbandry offers general, basic protection to all farm animals within the EU. However, Member States are free to adopt more rigorous national legislation.

4.1. Animal Welfare legislation for dairy cattle in the UE

The European Convention for the Protection of Animals kept for Farming Purposes (CE Farming Convention) is aimed at the practices of industrial stock breeding. The CE Farming Convention, purportedly drafted based on ethical principles, applies to the keeping, care and housing of animals, and in particular to animals in modern intensive stock farming systems. The general standard of treatment under the CE Farming Convention requires that:

Animals shall be housed and provided with food, water and care in a manner which having regard to their species and to their degree of development, adaptation and domestication is appropriate to the physiological and ethological needs in accordance with established experience and scientific knowledge.
To meet ethological needs, it is necessary that an animal be able to behave in a way consistent with its normal behavior in a natural setting.
To meet physiological and ethological needs, it is not only necessary to satisfy physical needs for survival, but also to meet behavioral and psychological parameters, so that an animal can live in a way consistent with its nature.

Other requirements of the CE Farming Convention include standards relating to freedom of movement, feeding of animals, lighting, temperature and ventilation conditions where animals are confined and inspection requirements. These requirements can presumably be met by any number of types of regulations and the Convention does not attempt to define precisely how the standards are to be met.

The Committee endeavored to elaborate principles which are precise enough to prevent a completely free interpretation, but wide enough to allow for different needs. The underlying idea is to avoid any unnecessary suffering or injury and to secure conditions that shall be inconformity with physiological and ethological needs of the individual animals.

The EU Community-wide legislation affecting on farm animal welfare of dairy cattle is collected on:

Council Directive 98/58/EC of 20 July 1998 concerning the protection of animals kept for farming purposes. This provides a basic framework requiring member states to enact legislation obliging owners or keepers to ensure the welfare of animals in their care and to ensure that the animals are not caused any unnecessary pain, suffering or injury. These rules reflect the so-called 'Five Freedoms' as adopted by the FAWC in the UK. This directive lays down the minimum welfare standards for the protection of all farmed animals.
Commission Decision 2000/50/EC of 17 December 1999 concerning minimum requirements for the inspection of holdings on which animals are kept for farming purposes (repealed).
Council Directive 91/629/EEC of 19 November 1991 laying down minimum standards for the protection of calves.

Furthermore, there is a project, Welfare Quality® (2009), funded by EU and designed by scientific researches to integrate the animal welfare on farm in the feeding chain to achieve social expectations and market requirements, as well as to provide practical science based tools and strategies to improve the welfare of farm animals and at slaughter.

The Welfare Quality® principles and criteria are based on the Five Freedom: good feeding involving absence of prolonged hunger and thirst; good housing, considering comfort around resting, thermal comfort and easy of movement; good health which includes absence of injuries, disease and pain induced by management procedures; appropriate behavior based on expression of social and others behaviors, good human-animal relationship and absence of general fear.

The Welfare Quality® project focused on measuring the magnitude of the outcomes, facilitating an assessment of dairy cow welfare irrespective of housing system and management. In contrast, the EFSA

Scientific Opinion on dairy cow welfare focused on identifying the hazards that lead to these negative welfare outcomes and then making recommendations to reduce or eliminate them.

Despite of the legislation, there is not yet a certification of animal welfare on dairies extended over the UE. In contrast, in the USA, The National Dairy Farm Program have reached almost 80% of the dairy farms involved in this voluntary program which operates as an education, evaluation and verification program for dairy animal well-being. It is made through the Dairy Animal Care Manual, which assessment is similar to the Animal Welfare Quality® Protocol 2009.

4.2. Animal Welfare legislation in Spain

In Spain, Decree 2715/78 of October 27th transferred all responsibilities for animal protection to the Ministry of Agriculture. The basic organizational structure of the Ministry of Agriculture, Food and Environment, is developed by Royal Decree 1130/2008, of July 4th, (BOE July 8th), it attaches to the General Department of Operations and Systems Traceability Agricultural and Livestock Resources department competence in animal welfare.

The implementation of the rules by the Autonomous Communities is according to the statutes of autonomy. Basic general rules on animal welfare on farms are Royal Decree 348/2000 of March 10, modified by RD 441/01 of the Council of 27 April. The decree is the transposition into Spanish law (32/2007, 7th November) of Directive 98/58 / EC, which includes the principles of provision of housing, food, water and the physiological and behavioral needs of the animal's care, according to the experience and scientific knowledge gained. It also includes requirements for the animal keepers and, among others, it provides the obligation of a logbook on the holding in which all medical treatments performed, and the number of dead animals discovered in the inspections should be carried out regularly are scored. Such registration should be kept for at least three years.In addition to this general law, there are specific regulations establishing conditions for rearing calves under 6 month characteristics.

5 Welfare Assessment in Dairy Cattle

Welfare assessment systems, for use in dairy farms, may differ according to both the definition of animal welfare, and the purpose of the welfare assessment. Therefore, it may be varied with the objective to certificate or control the level of welfare on specific farms, to evaluate the welfare in different production systems, or to serve as an advisory tool that allows the farmer to identify, prevent or solve welfare problems on farm (Johnsen et al., 2001). Thus, choice of welfare indicators and methods of measurement reflects the basic considerations of how animal welfare is understood.

Experience from previous studies (Sandøe et al., 1997) indicates a large variation between herds as regards animal welfare due to the effect of interactions between production system and management. Consequently, to improve animal welfare, there is a need for methods assessing animal welfare at herd level and allow the farmer to assess the development over time and to respond appropriately (Von Borell et al., 2001; Grandin, 2010).

These evaluations should be based on multi-criteria approaches; since no single measure can unequivocally be related to the welfare status. Therefore, animal welfare measurements may form the basis for the identification of causes of well-being problems (Welfare Quality®, 2009).

Using the animal welfare assessment on farm as a tool to describe potential hazards and to identify Critical Control Points (CCP) may help farmers in controlling and monitoring the production process (Grandin, 2000). The critical limits for each identified CCP must involve a measurable parameter (von Borell et al., 2001).

5.1. Measurements of Dairy-Cattle welfare

Selection and development of reliable and feasible measures for on farm assessment protocols could be challenging. Many indicators may possibly be relevant for inclusion in an operational welfare assessment system.

The recently adopted EU Strategy for the Protection and Welfare of Animals 2012-2015 highlights that the possibility of using scientifically validated outcome-based indicators complementing perspectives requirements in EU legislation will be considered when necessary (European Commission, 2012). The factors that affect an animal's welfare include the physical environment, resources available to the animal and the management practices of the farm. Depending on its characteristics (breed, sex, age, etc.) the animal will respond to these inputs and animal's responses are assessed using animal-based measures.

Measurements considered on the Welfare Quality® assessment are described as valid, because scientific based, repeatable, since same results regardless of time and observer and, feasible due to easily observation within areas on a reasonable time. Three areas of assessment have been developed and several measurements were included on each area:

Animal based indicators: injuries, body condition scoring, fear responses, lameness assessment, mortalities, milk quality, production records and health records.
Resource based measures: feed and water, space allowance, shade and shelter, flooring and housing system.
Management practices: maintenance records, herd health plans, emergency plans, training and skills and record keeping.

Animal-based measures are likely to highlight the most important and urgent welfare problems, and so focus priorities for remedial action. Resource- and management-based measures are more likely to highlight the potential risk of reduced welfare in the future and help to identify the reasons underlying current animal welfare problems. Thus, both animal-based and non-animal-based measures are needed in a control or assessment protocol (EFSA, 2012).

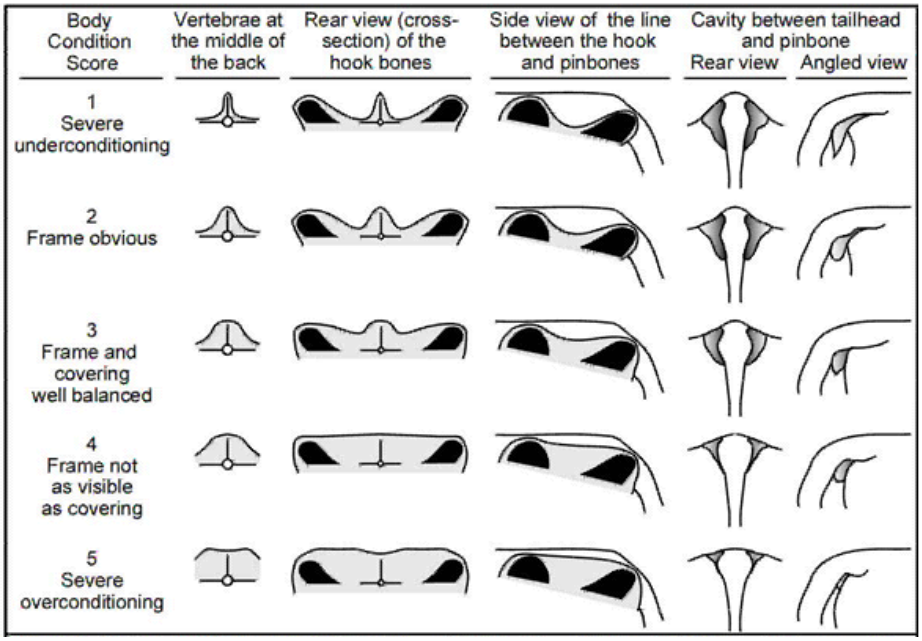
Previous assessments of animal welfare relied mainly on resource-based parameters, i.e. measures taken regarding the environment in which the animals are kept (Bartussek, 2001; Bracke et al., 2002). However, actual research are mostly focus on animal-based measures aim to directly measure the actual welfare status of the animal and thus include indirectly the effect of resource and management factors as well, because of their effect on the animal (Whay et al., 2003; von Keyserlingk et al., 2012).

The Welfare Quality® protocol involves 53 measurements assessed by questioning, direct observation of animals, management systems or records or a combination of both. However, observational assessments may be the cheapest and the fastest way to evaluate the animal well-being on farm.

5.1.1. Animal-based measurements

The Welfare Quality® comprises records of several animal-based measurements , i.e. cow diseases through clinical observations, coughing, nasal discharge, ocular discharge, hampered respiration, diarrhea, vulvar discharge, body condition, lameness, integument alterations, animal injuries suffered as result of housing equipment during lying down, hygiene, milk somatic cell count (SCC), mortality, dystocia, downer cows, disbudding/dehorning, tail docking, agonistic behaviors and avoidance distance at the feeding rack, lying time, time to lie down and animals lying partly or completely outside the lying area. However, most studies based on animal welfare (Whay et al., 2003; Cook, 2003; Main et al., 2003; Shearer, 2005; Espejo et al., 2006; Roche et al., 2009; Kielland et al., 2009; von Keyserlingk et al., 2012) mainly use observable and quantifiable measurements of the cow's body, i.e. body condition, injuries, lameness and body hygiene. Those scores may be the basis for a reference of cow health, cow comfort and management practices (Schreiner and Ruegg, 2003; Tucker et al., 2003, 2004; Chapinal et al., 2013; Barrientos et al., 2013; Garro et al., 2014).

Body condition scoring (BCS) is a quantitative tool for determining if an animal is too thin, too fat or in ideal condition depending upon stage of lactation (Coleen and Heinrichs, 2004). Advantages of this method might be found on the independence of the physiological status, rumen fill, cow's size or breed. Further, it is easy to learn and apply (no special equipment's) and difference between observers might be minimal if training and, it is also semi quantitative avoiding terms as "thin" or "fat". The scale used to measure BCS differs between systems, but low values always reflect emaciation and high values equate to obesity. As many measures are taken of the cow, it enhances the importance of the cow condition to production, reproduction, and cow health (Bewley and Schultz, 2008; Roche et al., 2009). BCS may be a valid indicator of animal welfare, but further research is required to determine the effect of BCS and BCS change on how a cow "feels" (Roche et al., 2009). Cows might be at an ideal BCS at dry off and might be fed to maintain this condition until calving. Gillund et al. (2001) confirmed the importance of BCS monitoring because ketotic cows lost significantly more body condition over a prolonged period of time than sound cows. The economic loss of one cow with subclinical ketosis is estimated to be $78 (Geishauser et al., 2001) and the average herd annual cost for an incidence rate of 41% in 100 cows was estimated on $3,198 (Duffield, 2000).



Picture 1.- Guidelines to measure BCS by Edmonson (1989)

Injuries of the skin were described on several studies and score systems were developed for different zones of the skin and housing type (Busato et al., 2000; Huxley and Whay, 2006; Fulwider et al., 2007; Kielland et al., 2009). Skin alterations are consequence of various causes, housing conditions and/or spacing and calving parity (Kielland et al., 2009). Hocks injuries, on the tarsal joints, are defined as hairless patches and lesions/swellings in an area extremely exposed and sensitive to pressure when the cow is lying down on a hard and/or abrasive surface with poor hygiene. These lesions cause pain and may force the animal to stand up or lie down for longer intervals (Haley et al., 2001).

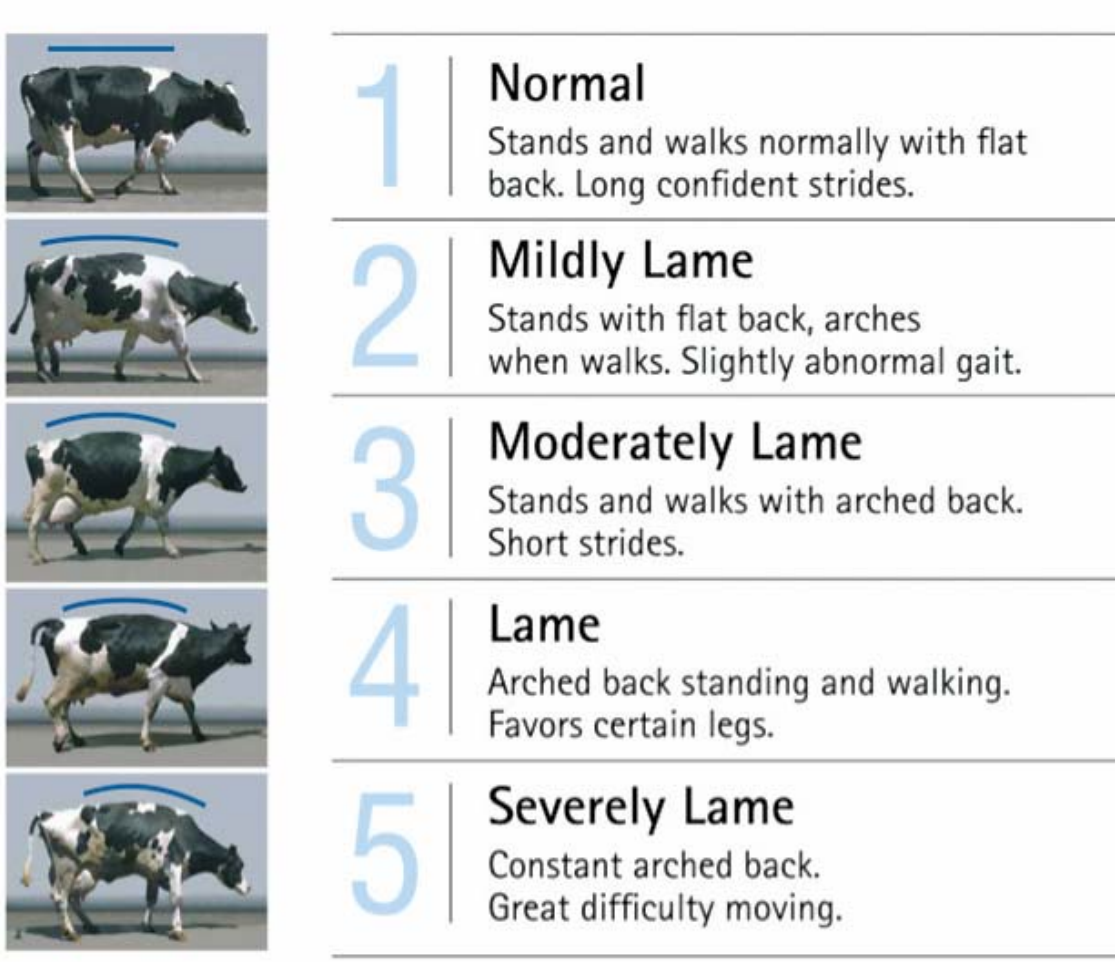
Picture 2.- Severity of hock injuries lesions. From right to left (1 to 4 score, big area affected and visible inflammation progressive)

Lameness is usually evaluated through scores to determine the level of severity lame. Sprecher et al. (1997) developed a locomotion scoring system (1 to 5) relatively easy for dairy producers to implement. Scores are based upon observation of the cow standing and walking with special emphasis on the cow's back posture. Cows should be scored when they are standing and walking on a flat surface that provides adequate traction. Due to the complexity of the locomotion assessment, studies are still developing and improving the score system (Thomsen et al., 2012; Hoffman et al., 2014), as they consider more cows signs to define the severity.

Lameness causes pain (Whay et al., 1997; O'Callaghan, 2003) that results in changes in cow behavior (Galindo and Broom, 2002) and it is therefore a significant threat to the well-being of dairy cows. Lameness can be developed through different diseases of the claw infections (foot root, sole ulcera, sole abscess and laminitis), injury, and penetration of foreign objects into the foot tissue or claw overgrowth. Also, several factors may result in increased incidence of non-infectious lesions of the hoof including inadequate management practices and poor facility design such as claw trimming (Raven, 1989; Shearer et al., 2005), flooring surfaces characteristic and conditions like grooving, slope, worn or slippery, and dirtiness (Cook, 2005; Kloosterman, 2005) and time standing (Nordlund et al., 2004; Cook et al., 2004; Shearer, 2005; Fregonesi et al., 2007; Schefers, 2008).

Furthermore, nutritional factors may contribute to lameness, i.e. feeding excessive amounts of rumen fermentable carbohydrates and/or protein, lack of effective fiber, sorting, inconsistent feeding times and inadequate trace mineral status as well as abrupt transition from dry cow to lactating cow both nutrition and environment (Nocek, 1997; Nocek et al., 2000; Cook et al., 2004; Cook, 2005). Further, lameness was related to reproduction failure, decreased milk production, increased culling risk, treatment costs and increased labor requirements (Sprecher et al., 1997; Warnick et al., 2001; Hernandez et al., 2002a; Hernandez et al., 2002b; Melendez et al., 2002; Juarez et al., 2003; Morris et al., 2011). Direct effects of

lameness account for 15% of culling in U.S. dairy herds (Cha et al., 2010). Based on these data, it has been estimated the indirect effects of lameness on production and reproduction could account for an additional 49% of culling in US dairy herds.



Picture 3.- Guidelines of locomotion score by Sprecher et al. (1997)

Body hygiene is an indicator of the environmental cleanliness at herd level. Contamination is transferred to the udder through the manure on the bed, contact with dirty rear legs, and splashes from the walking surfaces or tail contamination (Rousing et al., 2000; Fregonesi et al., 2007). Several methods of hygiene scoring have been documented for scoring different zones of the cows' coat but mainly focus on the rear limb, i.e. lower leg, udder and upper leg/flank (e.g. Cook, 2002; Schreiner and Ruegg, 2003; Reneau et al., 2005). Some of those systems have been used to prove that poor hygiene results in udder health problems, as manure may compromise the cow comfort increasing intramammary infections risk (Reneau et al., 2005).

Dirtiness is associated with increased risk of lameness and mastitis caused by poor slurry systems, lack of bedding materials, overstocking and poor stall dimensions (Philipot et al., 1994; Borderas et al., 2004; Fulwider et al., 2007; Schreiner and Ruegg, 2003). In those last three cases, cows may find alternatives to rest. It can be by different postures at the cubicles such as lying diagonal or perching, or locations in the barn such as lying in the alleys (Cook and Nordlund, 2004). Furthermore, hygiene at calving, sanitation and poor management practices as poor estrous detection has been related with herd breeding problems before than a nutritional cause (Chase et al., 1979).

Cleanliness of the feed bunk and water also contributes to maintain a good health. Fermentation of feed left from day prior or accumulate in corners, may induce to disease including generalized deterioration typical of protein deficiency, malnutrition, diarrhea, irritability, respiratory disease, abnormal behavior, mycotic abortions, and occasional death (Pier et al., 1980).

Picture 4.- Guidelines of hygiene scoring by Cook, University of Wisconsin

5.1.2. Facility-based measurements and management practices

Traditionally, the spacing of animals was influenced by environmental factors: weather, risk of predation, and the distribution of resources. However, for domesticated animals housed in intensive farming systems, social factors have a greater impact on spacing than environmental factors (Keeling and Duncan, 1991).
Hierarchies on a dairy herd used to be established by the length of the horns, however with the actual practices (dehorning), the cow size and temperament are the factors determining the hierarchies. A high correlation between social rank, body weight, and age has been described (Beilharz et al., 1966). Therefore, if new animals are not incorporated into a pen, hierarchies might be maintained over long time. Furthermore, competition and aggression were reported to increase when feeding space is reduced (Olofsson, 1999).
Cattle that are in socially stressful environments may be less productive, more susceptible to disease, and are more likely to experience reproductive difficulties (Friend and Polan, 1974; Dobson. et al., 2001). Therefore, appropriate and efficient design of stable facilities, equipment as well as inspection and handling routines are required to obtain and maintain good stockman ship in the herd (Rousing et al., 2000; Welfare Quality®, 2009). For this reason, measurements of the facilities may not be addressed by themselves because the design and conditions depends on the management practices carried by the farmer.
Dairy cows at approximately 100 percent stocking density in free-stall housing spend 3 to 5 hours per day feeding, consuming 9 to 14 meals per day. In addition, they ruminate 7 to 10 hours per day, spend approximately 30 minutes per day drinking, 2 to 3 hours per day outside the pen for milking and other management practices and require approximately 10 to 12 hours per day of lying time (Grant and Albright, 2001). Approximately 70 percent of the cow's day is spent eating and/or resting. Consequently, the cow only has, on average, 2.5 to 3.5 hours per day to spend outside the pen and away from the feed, water and stalls. Forcing the cow to spend more than this time outside the pen, she will need to give up something, typically feeding and/or resting.
For this reason, the Welfare Quality® comprises records of several resource- and management based measurements covering resting, walking, feeding, ventilation and milking. However, biosecurity might be also considered when external visits arrival or new animals are incorporated to the herd.

Resting area

Dairy cattle are highly motivated to lie down for approximately 12 hours per day (Munksgaard et al., 2005; Cook et al., 2005; Fregonesi et al., 2007; Gomez and Cook, 2010). The measured range in resting time for lactating Holstein cows of varying milk yield, days in milk (DIM), and BCS was 4.1 to 17.1 hours per day (Bewley et al., 2010). The range may reflect both cow and environmental factors.
Lying behavior takes precedence over eating and social behavior when opportunities to perform these behaviors are restricted (Munksgaard et al., 2005). Physiological function, health and productivity are impaired when the resting requirement is not met. Cows with restricted lying time have greater serum cortisol and lower growth hormone concentrations, impaired hoof health and locomotion and sometimes lower milk yield (Calamari et al., 2009).
An additional 1.5 hours per day standing time was associated with a 45-minute reduction in feeding time (Metz, 1985). Similarly, when cows experience a stocking density of 130 percent of stalls and headlocks preferred lying in free-stalls rather than feeding post-milking and spent more time in the alley waiting to lie down rather than feeding (Batchelder, 2000). Therefore, stocking density may affect animal welfare regarding feeding, drinking and resting (Fregonesi et al., 2007; McCarthy et al., 2007; Roche et al., 2007; Macdonald et al., 2008). Previous studies have shown overcrowding did not affect milk production (Hill et al., 2007; Krawczel et al., 2008); however variation on milk quality was reported through a decrease in milk fat and an increase in SCC (Hill et al., 2007).
Furthermore, stalls dimensions have been previously discussed and different results were obtained through research due to the wide range of variation on measurements and cow's size as well as management practices (Cook, 2002; Tucker et al., 2004, 2005; Fulwider et al., 2007; Fregonesi et al., 2009). For this reason, recommendations for stall dimensions are of the cow's size and behavior (Anderson, 2008). Similarly, different bedding materials have been widely described and compared, however results also depends on management practices (Cook, 2003; Schreiner and Ruegg, 2003; Cook and Nordlund, 2004;

Tucker et al., 2004, 2005; Fulwider et al., 2007; Fregonesi et al., 2009; Barrientos et. al., 2013; Chapinal et al., 2013). Therefore, those studies suggest well managed stalls may provide adequate comfort independent from the high variation on the design or quality of bedding materials and, the objectives may focus on avoid dirtiness and possible infections as well as pain or injuries.

Picture 5.- Cow resting on a short – length cubicle

Walking area

Cows may walk through wide corridors with no abrasive or smooth surfaces in order to allow heat expression, reduce competences like in overstocking (previously mentioned) and, avoid injuries and stressful reactions like with blocked alleys. To avoid high steps on the crossovers might be desirable as it helps on cows flow through the barn, decrease the risk of slippery or lesion and improve cleanliness when automatic scrapers are used (Magnusson et al., 2008). It is similarly to the rear curb height of the stalls, smaller curbs may be more attractive to enter in the stall (Cook, 2002; Anderson, 2007).

Further, management practices may not disturb cows nor impede their natural behavior, e.g. cleaning practices that could worn surfaces. In addition, rubber flooring has been described to improve the comfort of the cow as claw health and lameness (Vanegas et al., 2006) and therefore cows are more willing to move on and spend more time standing in front of the feed bunk when provided with softer flooring (Fregonesi et al., 2004; Telezhenko et al., 2007).

Also, footbath, when present, it is commonly placed on the walking area of the milking parlor or alleys. The main objective of the footbath is the control of early (subclinical) and chronic lesions, avoiding the progression of these lesions into acute (ulcerative) stages. Footbaths are not a substitute for individual treatment of acute lesions (Gomez, 2013).

A desirable cow comfort element to place on the alleys may be brushes. As environmental enrichment it satisfy grooming behavior needs, entertaining, diesstressing and improve cow cleanliness (Wilson et al., 2002; DeVries et al., 2007).

Picture 6.- Height of the curb across the walking area. It may interrupt linear and fuid circulation of the cows

Feeding area

Management practices at feed bunk, i.e. limited bunk space, limited feed access time, restricted feeding versus feeding for 5% to 10% refusal, inconsistent feeding schedule, infrequent push up of the ration and bunk competition (Milton, 1998), may increase the incidence of ruminal acidosis and laminitis because it promote cows eating fewer and larger meals more quickly. Furthermore, facilities design may also affect feeding behavior such as feeding the ration in a drive-by bunk 10 cm above the cow alley rate may decrease salivary flow and increase sorting which may develop acidosis (Albright, 1993).

The combination of limited bunk space and feed access time is worse than either situation alone. When overcrowding of free stalls coincides with limited bunk space, as is often the case, the potential for laminitis is greater because cows may spend more time standing on concrete rather than lying in stalls (Colam-Ainsworth et al., 1989). Further, overcrowding at headlocks negatively affects pregnancy rates (Wiltbank et al., 2007).

Estimates of water intake for cows in loose housing are 11 to 19 liters per minute from troughs (McFarland, 1998). Cows only spend about 12 to 15 minutes per day drinking water. The highest water intake periods are immediately following milking and during feed consumption. Therefore, provide water after milking and distribute it along the pen with availability for all cows, might be determinant for milk production. There are several factors that influence the animal's water intake and the most important ones are feed consumption, dry matter (DM) content in the diet, dry matter intake (DMI), production status (body weight) and ambient temperature (Murphy et al., 1983). Furthermore, dairy cows prefer and drink more from larger and deeper troughs (Pinheiro Machado Filho et al., 2004) as well as between 10 and 20°C (Andersson, 1984), temperatures less than 10°C, the cows yield 0.8 kg less milk per day (Himmel, 1964).

Therefore, the design and maintenance of drinkers will affect the quality of the water. The water in the drinkers may become polluted with faeces, urine, feed remnants, detritus, algae and other organisms that will reduce water quality. Troughs should be designed so they can be easily emptied and cleaned on a regular basis.

Common signs of poor quality and quantity of water intake in lactating dairy cows include depressed immune function (elevated SCC), increased reproductive failure, i.e. conception failure and early embryonic death/abortions, increased off-feed events and erratic eating patterns (Murphy et al., 1983; Adams and Sharpe, 1995).

For all those reasons, facilities design are involved in the health of the cows and should be constructed to minimize the time cows are away from feed and water (Smith et. al, 2002). However, feeding management practices, e.g. method of feeding (restrictive or ad libitum), homogeneity of a ration (mixing time), number of deliveries, consistency on the distribution of the ration on the feed bunk (feeder skills and mixer characteristics), may be a key factor for providing the cow with the formulated requirements.

Feeding management practices

Feed is the most expensive cost on a dairy representing 61% of the total production cost (CDFA, 2013). When ration fed differs from the formulated one, cows will not achieve their maximum production potential and some nutrients (i.e. nitrogen) will be wasted in manure rather than converted to milk.

There are five types of rations on a farm where variation in nutrient content of the ration will increase and be affected by feed management through each stage of creating the final ration (Kertz, 1998). The formulated diet is the diet prepared by the nutritionist to meet the cow or pen requirements, the working diet is the modified diet because the ingredients used in the ration preparation may not have the same nutrient composition that from what was used in ration formulation, the prepared diet is the diet as modified by the feeder because of weighing errors, or inadequate mixing, the consumed diet is the diet modified by the cow sorting behavior and, digested diet is the diet modified by digestion, for example lack of processing of corn silage may result in corn grains passing through without being digested.

Total mixed rations (TMRs) are formulated to contain a combination of feedstuffs that provide the right balance of nutrients in every bite consumed therefore, poor management practices on the preparation and distribution of a ration (uniformity mixing and delivery) can lead in behavior changes, as sorting activity and, consequently negatively impact animal performance and health through metabolic issues, such as sub-acute ruminal acidosis (Stone, 2004; Devries et al., 2008).

Silva-del-Rio and Castillo (2012) found a difference of -2 to 4 percentage units of crude protein (CP) between the formulated and the analyzed CP in seven dairies in Merced County. Rossow and Aly (2013) showed lignin, fat, and ash as best indices of feed management to include effects of variability in nutrients on variability in milk yield, milk fat, and milk protein percentages in ration formulation models.

Monitoring cow rations may ensure that specific dietary ingredients are kept at safe levels (Hansen, 2007). Oelberg and Stone (2014) had reported variation on TMR composition and distribution along the feedbunk through a TMR Audit system developed by Diamond V. For this reason, precision and accuracy, as well as adequate mixing time for the load weight during ingredient loading is needed to improve the efficiency of production, decrease feed cost and decrease the nutrients with an environmental impact (James y Cox, 2008).

The ration formulated may vary on farm frequently because several changes as the number of ingredients, ingredient type, inclusion rate or ingredient DM. Several of those factors are related with the specific physical and chemical characteristics of the ingredients such as DM content, particle length, shape and density however they could not be adjusted or improved on farm. This variation is more dependent on market prices or environmental conditions which cannot be controlled from the inside farm. However, the ration preparation is a process which mainly depends on farm management practices because it involves feeder job and equipment availability such as feed wagon or loader weigh cells calibration and maintenance. In this regard, variables as deviation from the target weight, mixing times or over/under filling can be evaluated, controlled, trained and improved on farm (Weiss et al., 2013).

Several of the commercially available computerized feed management software systems (EZfeed, www.dhiprovo.com; Feed Supervisor, www.feedsupervisor.com; Feed Watch, www.vas.com; TMR Tracker, www.digi-star.com) can keep records of the ration preparation as actual weights and times (Bucholtz, 2002). The systems can improve a feeder's accuracy and efficiency both through making their responsibilities easier to accomplish, because feeder can be monitored. Dry matters and rations can be updated by the feeder in the bunk or by someone else at the dairy office. The change in ingredient dry matter is then updated automatically in all rations. The systems typically come with a highly visible scale display to place in the feed wagon and make the feeder job easier. The systems can also record the accuracy with which each ingredient was added to a load, the time between ingredients, the time needed to prepare the entire load, and the total mixing time. Provided that dry matters and cow numbers are correct, and that refusals at the end of the day are measured, an accurate assessment of DMI can be obtained. Additionally, the software systems help in inventory management and to reduce shrink.

However, not all actions can be traced by the software and observational monitoring programs are needed on farm. Incorrect and inconsistent TMR mixes can arise from mismanagement of the mixing process. Therefore, sampling the bunk mix and performing a nutrient and particle size analysis may help to avoid those issues. Oelberg and Stone (2014) had observed through an audit process nine main factors in the TMR mixing process that can each create variation in the TMR, i.e. worn parts of the mixer such as augers, kicker plates, and knives, mixing time after the last added ingredient, unlevel mixers, loading position on the mixer box, load size commonly too small for the reduced group of close-up cows, hay quality and processing, loading sequence of ingredients into the mixer, liquid distribution and vertical mixer auger speed. One of the main goals to reduce variation comes from silages (corn silage, haylage, hay), which are the major ingredients included in the TMR. Management practices with silages may minimize dry matter (DM), nutrient variation and silage spoilage. Facing silage from bunkers and piles and premixing the defaced silage with a loader bucket or mixer wagon makes the silage more consistent in moisture and nutrients and it is a key to minimizing variation between formulated and prepared diets (Oelberg and Stone, 2014).

Feeder job should be focus on avoid variation in the loading process. Errors in accuracy and precision can be attributed to variability in feedstuffs and/or operator error. However, settings of tolerance level (TL), which allow a certain deviation under the target, may decrease the precision and accuracy because it depends on the ratio kg of TL/kg of target weight.

Further, software does not recognize ingredients type. Therefore, some cheating can be performed such as the replacement of an ingredient targeted for another one or jumping to next ingredient without loading the next one which can be done directly with the computer, pushing the front-end-loader in the mixer wall, or replacing the next ingredient for the leftovers of the previous one. Those actions can be only detected on the system through a short period of time between ingredients.

The total mixing time should allow the homogeneity of the final ration. Adequate mixing time is a function of mixer characteristics, i.e. horizontal or vertical auger, capacity, interior design, number of augers, kickers and knives and horse power, as well as recipe characteristic, i.e. ingredient type such as wet ingredients might steak to others or long particle forages need more time to allow homogeneity on the ration, order of ingredients into the recipe which may be by increasingly density from first to last, number of ingredients, and load weight.

Most manufactures recommended between 2 to 5 minutes after last ingredient load, however, there is no researcher basis to this statement. To monitor the homogeneity of the TMR the Penn State-Nasco shaker box could be use on farm (Oelberg and Stone, 2014). It is recommended that the TMR contain 8% to 10% (as-fed basis) coarse particles or particles on the top screen of the shaker box. In a survey of 49 commercial dairies, Possin et al. (1995) reported coarse particle fractions of 7.6% and 4.8% (as-fed basis) for TMR mixed for < 15 min or > 15 min, respectively. Furthermore, they reported TMR coarse particle fractions of 7.9% and 3.5% (as-fed basis) in low-and high-incidence herds for laminitis, respectively.

Day to day variation on the physical properties and nutrient composition of the ration fed is unavoidable; therefore, operating time of mixing equipment should be sufficient to prevent sorting of long particles because it can negatively impact animal performance and health i.e. displaced abomasums and fluctuations in average daily milk yield (Stone, 2004; DeVries et al., 2008; Sova et al., 2014; Rossow and Aly, 2014). Variation in the amount loaded also affects the nutritional value of the ration. Compensations on weight could be made adding another ingredient instead of the targeted one, however nutritional values (NDF, ADF, CP, …) vary within and across ingredient type.

Monitoring ration delivery through Software may help achieve objectives measured as kg/cow but not necessary on nutritional components to meet the formulated ration.

Picture 7.- Particle processing vary with initial particle length and presenting shape of the feed (ex. hay visible in the top of the ration on the botton picture was dropped in packages), the individual mixing and chopping time as well overall time (ex. hay botton picture had a short chopping/mixing time) and dry matter content will influence the capability of chopping. Size and volume will affect distribution on the ration and dropping order of the ingredients will determine homogeneity (heaviest ingredients will go down faster so dropping them at end is a recommended practice)

Ventilation area

Cows must adapt to each environment thermal characteristic of a geographical area and maintain homeothermy (constant temperature) using the body thermoregulatory mechanisms.

Heat stress may occur when the body cannot remove heat actively in situations of high temperatures. This affects increasing energy expenditure for maintenance, reducing DMI, increasing losses of water and minerals, altering the acid-base balance, changing the blood flow to organs and changes in biochemical and hormonal modifications (West, 2003; Arias e col., 2008). Heat stressed cows eat less and this nutrition deficit results in prolonged postpartum anestrus and impaired embryonic development. In addition, this inadequate nutrient intake reduces BCS and causes cessation of estrus cycles. Symptoms induced by heat stress gradually pile on, and the ultimate result is that the success of gestation is severely compromised even after the weather has moderated (Jordan, 2003; West, 2004).

As any chronic forms of stress, cows can experience metabolic changes which can result in stress-related illnesses and depressed immunity. This can lead to a lowering of the cow's defense against mastitis-causing pathogens. And it could be enhanced by the humidity levels. Therefore, ventilation and humidity might constitute two main factors on the design of the barn, as well as barn orientation (Buxadé, 1998). Cows are at risk of heat stress when temperature humidity index of 72, which corresponds to 22°C at 100% humidity, 25°C at 50% humidity, or 28°C at 20% humidity (Ravagnolo et al., 2000; Jordan, 2003).
Signs of poor ventilation include condensation on the ceiling and walls, steamy conditions and ammonia odor. Improving the natural ventilation in old free stall barns can be accomplished by opening the ridge caps and eaves.

One of the best practices to reduce heat stress is to provide adequate fresh, cool, clean drinking water. Other methods of cooling include shade, commercial coolers, tunnel ventilation, shower/fanning stations, fans, cooling ponds and center pivots. Shade alone will reduce a cow's respiration rate by 30%, and adding sprinklers will reduce the respiration rate by 67% (Kendall et al., 2007). Sprinkling or soaking with water, along with supplemental airflow has been shown to reduce respiration rates by 18-41%, improve DMI by 7-9% and increase milk yield by 9-16% (Bucklin, 1991; West, 2003). Once the temperature goes above 25ºC cows will reduce feed intake. Providing fresh air in the feeding area during hot weather, above 20ºC, will help to decrease heat stress, gives the cow the opportunity to breathe easily, keeps cows eating and also helps to keep flies away from the feeding area (Flamenbaum and Galon, 2010).

Further, cleanliness and ventilation might be linked to control cow disease. Dirtiness on the coat can increase the risk of disease due to microbial growth. Issues may start with skin irritation and evolution will depend on cow's body zone and the exposure to manure. Well-ventilated facilities may help to avoid microorganism proliferation.

Picture 8.- Promoting natural ventilation will help to maintain a healthy environment. Open sides ensure air circulation through the barn

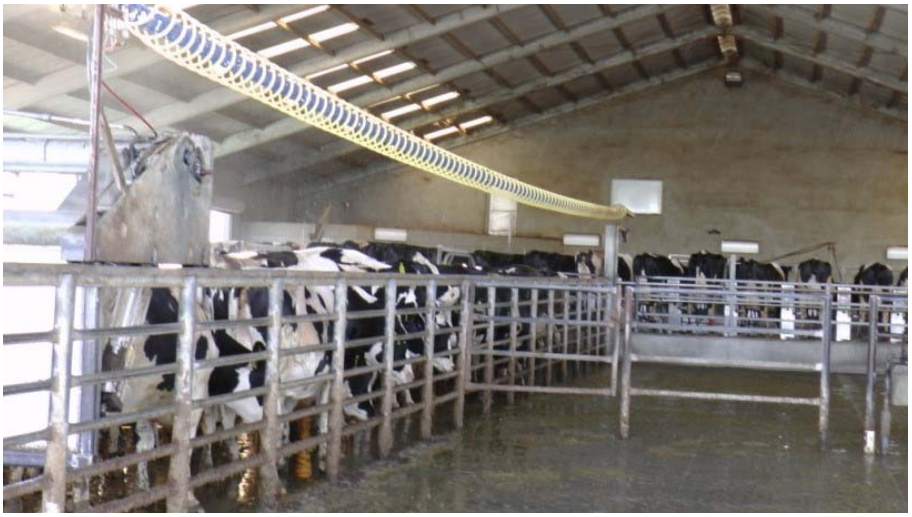
Milking area

Quality milk may start with quality management; therefore hygienic conditions as well as adjustments of the milking machines, both are the most important practices in this area of the barn to ensure animal well-being. Further, milking dirty cows will also affect milk quality but it will reduce milking speed in the parlour, i.e. 20% fewer cows per hour affected. The efficiency of the milking parlor is measured by the number of cows per hour which will depend on the entrance speed and that is of the parlor lenght, number of cows by place, number of operators by cow and liters milked by operator which varied with the operator walking distance, being higher in automated side opening parlors and lowest in rotary parlors (Smith et al., 1998).

To keep constant milk production, schedules and routines during milking should be considered as well (Smith et al., 1998; Armstrong et al., 2001).

Management practices and facilities design such as time standing in the holding pen, space available per cow in the holding pen, treatment of the cows when pushing into the holding pen and/or milking parlour may develop stress and therefore affect oxytocine release compromising the pre-milking.

Negative animals' handling experiences results with higher level of fear of man and negative effects on production, reproduction, welfare and increasing the risk of injuries for both, animal and human (Seabrook, 1972; Hemsworth and Coleman 2000; Waiblinger et al., 2002).



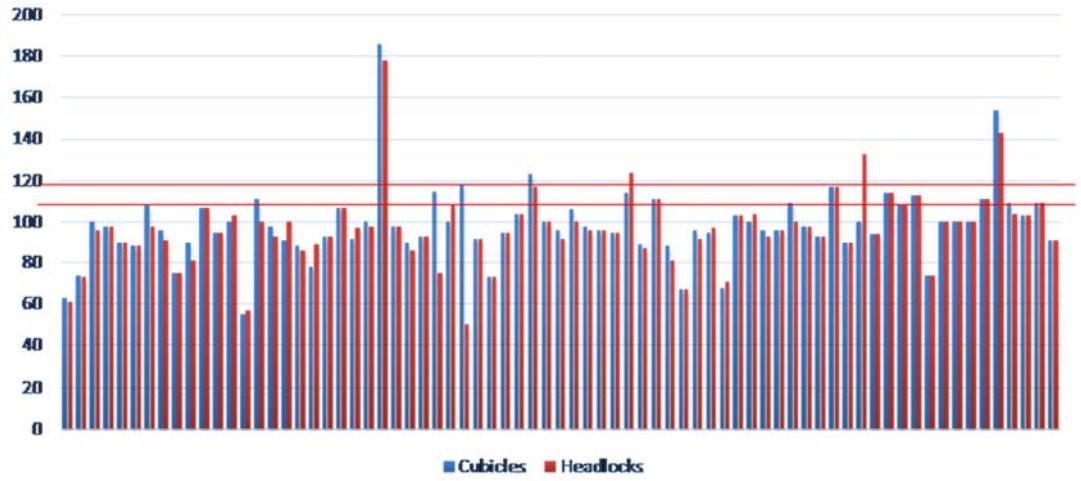
Picture 9.- Linear paths across the milking parlor will contribute with natural cow's flow entering and leaving the milking parlor

6 Benchmarking process

Jackson and Lund (2000) had provided a definition of benchmarking, as a framework for continuous improvement. They have it defined as, first and foremost, to be a learning process structured so as to enable those engaged in the process to compare their performance in order to identify their comparative strengths and weaknesses as a basis for self-improvement and/or self–regulation.
A benchmark is a point of reference to make comparisons, usually implying that it is a good basic standard to achieve. It implies to identify what are the most useful indicators, rather than what is easiest to measure. A benchmark can highlight a problem area, potential for improvement, incentive to change and assist in setting targets. For this reason, the Animal Welfare Science Centre has reported effective monitoring scheme based on good scientific basis satisfy public, industry and political views of animal welfare and active involvement from and feedback to producers.

Benchmarking is being increasingly used to track changes within the same farm over time, i.e. monitoring, or more often, to compare farms, i.e. learn best management practices and benefit from others. When the same animal-based measure is compared between farms with similar housing systems and management practices, it facilitates the identification of those farms that are outside the normal range of variation and this information also becomes relevant to the assessment of dairy cow welfare (EFSA, 2012).

The reasons to benchmark the animal welfare are based on assess industry performance, demonstrate and instill trust in consumers that welfare standards are being met to protect international markets, to assist and demonstrate continuous improvement.



Picture 10.- Graph of the stocking density within cubicles and headlocks by dairy in 73 dairy farms in Northwest of Spain. Showing these results in figures may allow farmers to understand where are they positioned regarding others and engage to change management practices

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Procedemento editorial
A Revista Recursos Rurais aceptará para a súa revisión artigos, revisións e notas vinculados á investigación e desenvolvemento tecnolóxico no ámbito da conservación e xestión da biodiversidade e do medio ambiente, dos sistemas de produción agrícola, gandeira, forestal e referidos á planificación do territorio, tendentes a propiciar o desenvolvemento sostíbel dos recursos naturais do espazo rural.Os artigos que non se axusten ás normas da revista, serán devoltos aos seus autores.

Preparación do manuscrito

Comentarios xerais
Os manuscritos non deben exceder de 20 páxinas impresas en tamaño A4, incluíndo figuras, táboas, ilustracións e a lista de referencias. Todas as páxinas deberán ir numeradas, aínda que no texto non se incluirán referencias ao número de páxina. Os artigos poden presentarse nos seguintes idiomas: galego, castelán, portugués, francés ou inglés. Os orixinais deben prepararse nun procesador compatíbel con Microsoft Word ®, a dobre espazo nunha cara e con 2,5 cm de marxe. Empregarase a fonte tipográfica "arial" a tamaño 11 e non se incluirán tabulacións nin sangrías, tanto no texto como na lista de referencias bibliográficas. Os parágrafos non deben ir separados por espazos. Non se admitiran notas ao pe.
Os nomes de xéneros e especies deben escribirse en cursiva e non abreviados a primera vez que se mencionen. Posteriormente o epíteto xenérico poderá abreviarse a unha soa letra. Debe utilizarse o Sistema Internacional (SI) de unidades. Para o uso correcto dos símbolos e observacións máis comúns pode consultarse a última edición do CBE (Council of Biology Editors) Style manual.

Páxina de Título
A páxina de título incluirá un título conciso e informativo (na lingua orixinal e en inglés), o nome(s) do autor(es), a afiliación(s) e a dirección(s) do autor(es), así como a dirección de correo electrónico, número de teléfono e de fax do autor co que se manterá a comunicación.

Resumo
Cada artigo debe estar precedido por un resumo que presente os principais resultados e as conclusións máis importantes, cunha extensión máxima de 200 palabras. Ademais do idioma orixinal no que se escriba o artigo, presentarase tamén un resumo en inglés.

Palabras clave
Deben incluírse ata 5 palabras clave situadas despois de cada resumo distintas das incluídas no título.

Organización do texto
A estructura do artigo debe axustarse na medida do posíbel á seguinte distribución de apartados: Introdución, Material e métodos, Resultados e discusión, Agradecementos e Bibliografía. Os apartados irán resaltados en negriña e tamaño de letra 12. Se se necesita a inclusión de subapartados estes non estarán numerados e tipografiaranse en tamaño de letra 11.

Introdución
A introdución debe indicar o propósito da investigación e prover unha revisión curta da literatura pertinente.

Material e métodos
Este apartado debe ser breve, pero proporcionar suficiente información como para poder reproducir o traballo experimental ou entender a metodoloxía empregada no traballo.

Resultados e Discusión
Neste apartado exporanse os resultados obtidos. Os datos deben presentarse tan claros e concisos como sexa posíbel, se é apropiado na forma de táboas ou de figuras, aínda que as táboas moi grandes deben evitarse. Os datos non deben repetirse en táboas e figuras. A discusión debe consistir na interpretación dos resultados e da súa significación en relación ao traballo doutros autores. Pode incluírse unha conclusión curta, no caso de que os resultados e a discusión o propicien.

Agradecementos
Deben ser tan breves como sexa posíbel. Calquera concesión que requira o agradecemento debe ser mencionada. Os nomes de organizacións financiadoras deben escribirse de forma completa.

Bibliografía
A lista de referencias debe incluír unicamente os traballos que se citan no texto e que se publicaron ou que foron aceptados para a súa publicación. As comunicacións persoais deben mencionarse soamente no texto. No texto, as referencias deben citarse polo autor e o ano e enumerar en orde alfabética na lista de referencias bibliográficas.

Exemplos de citación no texto:
Descricións similares danse noutros traballos (Fernández 2005a, b; Rodrigo et al. 1992).
Andrade (1949) indica como....
Segundo Mario & Tineti (1989) os factores principais están....
Moore et al. (1991) suxiren iso...

Exemplos de lista de referencias bibliográficas:
Artigo de revista:
Mahaney, W.M.M., Wardrop, D.H. & Brooks, P. (2005). Impacts of sedimentation and nitrogen enrichment on wetland plant community development. Plant Ecology. 175, 2: 227-243.
Capítulo nun libro:
Campbell, J.G. (1981). The use of Landsat MSS data for ecological mapping. En: Campbell J.G. (Ed.) Matching Remote Sensing Technologies and Their Applications. Remote Sensing Society. London.
Lowel, E.M. & Nelson, J. (2003). Structure and morphology of Grasses. En: R.F. Barnes et al. (Eds.). Forrages. An introduction to grassland agriculture. Iowa State University Press. Vol. 1. 25-50
Libro completo:
Jensen, W (1996). Remote Sensing of the Environment: An Earth Resource Perspective. Prentice-Hall, Inc. Saddle River, New Jersey.
Unha serie estándar:
Tutin, T.G. et al. (1964-80). Flora Europaea, Vol. 1 (1964); Vol. 2 (1968); Vol. 3 (1972); Vol. 4 (1976); Vol. 5 (1980). Cambridge University Press, Cambridge.
Obra institucional:
MAPYA (2000). Anuario de estadística agraria. Servicio de Publicaciones del MAPYA (Ministerio de Agricultura, Pesca y Alimentación), Madrid, España.
Documentos legais:
BOE (2004). Real Decreto 1310/2004, de 15 de enero, que modifica la Ley de aprovechamiento de residuos ganaderos. BOE (Boletín Oficial del Estado), nº 8, 15/1/04. Madrid, España.
Publicacións electrónicas:
Collins, D.C. (2005). Scientific style and format. Dispoñíbel en: http://www.councilscience.org/publications.cfm [5 xaneiro, 2005]
Os artigos que fosen aceptados para a súa publicación incluiranse na lista de referencias bibliográficas co nome da revista e o epíteto "en prensa" en lugar do ano de publicación.

Ilustracións e táboas

Todas as figuras (fotografías, gráficos ou diagramas) e as táboas deben citarse no texto, e cada unha deberá ir numerada consecutivamente. As figuras e táboas deben incluírse ao final do artigo, cada unha nunha folla separada na que se indicará o número de táboa ou figura, para a súa identificación. Para o envío de figuras en forma electrónica vexa máis adiante.
Debuxos lineais. Por favor envíe impresións de boa calidade. As inscricións deben ser claramente lexíbeis. O mínimo grosor de liña será de 0,2 mm en relación co tamaño final. No caso de Ilustracións en tons medios (escala de grises): Envíe por favor as impresións ben contrastadas. A ampliación débese indicar por barras de escala. Acéptanse figuras en cores.

Tamaño das figuras
As figuras deben axustarse á anchura da columna (8.5 centímetros) ou ter 17.5 centímetros de ancho. A lonxitude máxima é 23 centímetros. Deseñe as súas ilustracións pensando no tamaño final, procurando non deixar grandes espazos en branco. Todas as táboas e figuras deberán ir acompañadas dunha lenda. As lendas deben consistir en explicacións breves, suficientes para a comprensión das ilustracións por si mesmas. Nas mesmas incluirase unha explicación de cada unha das abreviaturas incluídas na figura ou táboa. As lendas débense incluír ao final do texto, tras as referencias bibliográficas e deben estar identificadas (ex: Táboa 1 Características...). Os mapas incluirán sempre o Norte, a latitude e a lonxitude.

Preparación do manuscrito para o seu envío

Texto
Grave o seu arquivo de texto nun formato compatíbel con Microsoft Word.

Táboas e Figuras
Cada táboa e figura gardarase nun arquivo distinto co número da táboa e/ou figura. Os formatos preferidos para os gráficos son: Para os vectores, formato EPS, exportados desde o programa de debuxo empregado (en todo caso, incluirán unha cabeceira da figura en formato TIFF) e para as ilustracións en tons de grises ou fotografías, formato TIFF, sen comprimir cunha resolución mínima de 300 ppp. En caso de enviar os gráficos nos seus arquivos orixinais (Excel, Corel Draw, Adobe Ilustrator, etc.) estes acompañaranse das fontes utilizadas. O nome do arquivo da figura (un arquivo diferente por cada figura) incluirá o número da ilustración. En ningún caso se incluirá no arquivo da táboa ou figura a lenda, que debe figurar correctamente identificada ao final do texto. O material gráfico escaneado deberá aterse aos seguintes parámetros: Debuxos de liñas: o escaneado realizarase en liña ou mapa de bits (nunca escala de grises) cunha resolución mínima de 800 ppp e recomendada de entre 1200 e 1600 ppp. Figuras de medios tons e fotografías: escaneararse en escala de grises cunha resolución mínima de 300 ppp e recomendada entre 600 e 1200 ppp.

Recepción do manuscrito
Os autores enviarán un orixinal e dúas copias do artigo completo ao comité editorial, xunto cunha copia dixital, acompañados dunha carta de presentación na que ademais dos datos do autor, figuren a súa dirección de correo electrónico e o seu número de fax, á seguinte dirección:

IBADER
Comité Editorial da revista Recursos Rurais
Universidade de Santiago.
Campus Universitario s/n
E-27002 LUGO - Spain

Enviar o texto e cada unha das ilustracións en arquivos diferentes, nalgún dos seguintes soportes: CD-ROM ou DVD para Windows, que irán convenientemente rotulados indicando o seu contido. Os nomes dos arquivos non superarán os 8 caracteres e non incluirán acentos ou caracteres especiais. O arquivo de texto denominarase polo nome do autor.

Ou ben enviar unha copia digital dos arquivos convintemente preparados á dirección de e-mail:
ibader@.usc.es

Cos arquivos inclúa sempre información sobre o sistema operativo, o procesador de texto, así como sobre os programas de debuxo empregados nas figuras.

Decembro 2015

Recursos Rurais

Revista do Instituto de Biodiversidade Agraria e Desenvolvemento Rural (IBADER)

Proceso de selección y evaluación de originales

Recursos Rurais publica artículos, revisiones, notas de investigación y reseñas bibliográficas. Los artículos, revisiones y notas deben ser originales, siendo evaluados previamente por el Comité Editorial y el Comité Científico Asesor. Los trabajos presentados a Recursos Rurais serán sometidos a la evaluación confidencial de dos expertos ajenos al equipo editorial, siguiendo criterios internacionales. En el caso de que los evaluadores propongan modificaciones en la redacción del original, será responsabilidad del equipo editorial -una vez informado el autor- el seguimiento del proceso de reelaboración del trabajo. Caso de no ser aceptado para su edición, el original será devuelto a su autor, junto con los dictamenes emitidos por los evaluadores.
En cualquier caso, los originales que no se ajusten a las siguientes normas técnicas serán devueltos a sus autores para su corrección, antes de su envío a los evaluadores.

Normas para la presentación de originales

procedimiento editorial
La Revista Recursos Rurais aceptará para a su revisión artículos, revisiones y notas vinculados a la investigación y desenvolvimiento tecnológico en el ámbito de la conservación y gestión de la biodiversidad y del medio ambiente, de los sistemas de produción agrícola, ganadera, forestal y referidos a la planificación del territorio, tendientes a propiciar el desarrollo sostenible de los recursos naturales del espacio rural y de las áreas protegidas.Los artículos que no se ajusten a las normas de la revista, serán devueltos a sus autores.

Preparación del manuscrito

Comentarios generales
Los manuscritos no deben exceder de 20 páginas impresas en tamaño A4, incluyendo figuras, tablas, ilustraciones i la lista de referencias. Todas las paginas deberán ir numeradas, aunque en el texto no se incluirán referencias al número de pagina. Los artículos pueden presentarse en los siguientes idiomas: galego, castellano, portugués, francés o inglés. Los originales deben prepararse en un procesador compatible con Microsoft Word ®, a doble espacio en una cara y con 2,5 cm de margen. Se empleará la fuente tipográfica "arial" a tamaño 11 y no se incluirán tabulaciones ni sangrías, tanto en el texto como en la lista de referencias bibliográficas. Los parágrafos no deben ir separados por espacios. No se admitirán notas al pie.
Los nomes de géneros ye especies deben escribirse en cursiva y no abreviados la primera vez que se mencionen. Posteriormente el epíteto genérico podrá abreviarse a una sola letra. Debe utilizarse el Sistema Internacional (SI) de unidades. Para el uso correcto de los símbolos y observaciones más comunes puede consultarse la última edición do CBE (Council of Biology Editors) Style manual.

Pagina de Título
La pagina de título incluirá un título conciso e informativo (en la lengua original y en inglés), el nombre(s) de los autor(es), la afiliación(s) y la dirección(s) de los autor(es), así como la dirección de correo electrónico, número de teléfono y de fax del autor con que se mantendrá la comunicación.

Resumen
Cada articulo debe estar precedido por un resumen que presente los principales resultados y las concusiones más importantes, con una extensión máxima de 200 palabras. Ademas del idioma original en el que se escriba el articulo, se presentará también un resumen en inglés.

Palabras clave
Deben incluirse hasta 5 palabras clave situadas después de cada resumen, distintas de las incluidas en el título.

Organización del texto
La estructura del articulo debe ajustarse en la medida de lo posible a la siguiente distribución de apartados: Introducción, Material y métodos, Resultados y discusión, Agradecimientos y Bibliografía. Los apartados irán resaltados en negrita y tamaño de letra 12. Si se necesita la inclusión de subapartados estos no estarán numerados y se tipografiaran en tamaño de letra 11.

Introducción
La introducción debe indicar el propósito de la investigación y proveer una revisión corta de la literatura pertinente.

Material y métodos
Este apartado debe ser breve, pero proporcionar suficiente información como para poder reproducir el trabajo experimental o entender la metodología empleada en el trabajo.

Resultados y Discusión
En este apartado se expondrán los resultados obtenidos. Los datos deben presentarse tan claros y concisos como sea posible, si es apropiado en forma de tablas o de figuras, aunque las tablas muy grandes deben evitarse. Los datos no deben repetirse en tablas y figuras. La discusión debe consistir en la interpretación de los resultados y de su significación en relación al trabajo de otros autores. Puede incluirse una conclusión corta, en el caso de que los resultados y la discusión lo propicien.

Agradecimientos
Deben ser tan breves como sea posible. Cualquier concesión que requiera el agradecimiento debe ser mencionada. Los nomes de organizaciones financiadoras deben escribirse de forma completa.

Bibliografía
La lista de referencias debe incluir unicamente los trabajos que se citan en el texto y que estén publicados o que hayan sido aceptados para su publicación. Las comunicaciones personales deben mencionarse solamente en el texto. En el texto, las referencias deben citarse por el autor y el año y enumerar en orden alfabética en la lista de referencias bibliográficas.

ejemplos de citación en el texto:
Descripciones similares se dan en otros trabajos (Fernández 2005a, b; Rodrigo et al. 1992).
Andrade (1949) indica como....
según Mario & Tineti (1989) los factores principales están....
Moore et al. (1991) sugieren eso...

Ejemplos de lista de referencias bibliográficas:
Artículo de revista:
Mahaney, W.M.M., Wardrop, D.H. & Brooks, P. (2005). Impacts of sedimentation and nitrogen enrichment on wetland plant community development. Plant Ecology. 175, 2: 227-243.
Capítulo en un libro:
Campbell, J.G. (1981). The use of Landsat MSS data for ecological mapping. En: Campbell J.G. (Ed.) Matching Remote Sensing Technologies and Their Applications. Remote Sensing Society. London.
Lowel, E.M. & Nelson, J. (2003). Structure and morphology of Grasses. En: R.F. Barnes et al. (Eds.). Forrages. An introduction to grassland agriculture. Iowa State University Press. Vol. 1. 25-50
Libro completo:
Jensen, W (1996). Remote Sensing of the Environment: An Earth Resource Perspective. Prentice-Hall, Inc. Saddle River, New Jersey.
Una serie estándar:
Tutin, T.G. et al. (1964-80). Flora Europaea, Vol. 1 (1964); Vol. 2 (1968); Vol. 3 (1972); Vol. 4 (1976); Vol. 5 (1980). Cambridge University Press, Cambridge.
Obra institucional::
MAPYA (2000). Anuario de estadística agraria. Servicio de Publicaciones del MAPYA (Ministerio de Agricultura, Pesca y Alimentación), Madrid, España.
Documentos legales:
BOE (2004). Real Decreto 1310/2004, de 15 de enero, que modifica la Ley de aprovechamiento de residuos ganaderos. BOE (Boletín Oficial del Estado), nº 8, 15/1/04. Madrid, España.
Publicaciones electrónicas:
Collins, D.C. (2005). Scientific style and format. Dispoñíbel en: http://www.councilscience.org/publications.cfm [5 xaneiro, 2005]
Los artículos que fuesen aceptados para su publicación se incluirán en la lista de referencias bibliográficas con el nombre de la revista y el epíteto "en prensa" en lugar del año de publicación.

Ilustraciones y tablas

Todas las figuras (fotografías, gráficos o diagramas) y las tablas deben citarse en el texto, y cada una deberá ir numerada consecutivamente. Las figuras y tablas deben incluirse al final del artículo, cada una en una hoja separada en la que se indicará el número de tabla o figura, para su identificación. Para el envío de figuras en forma electrónica vea más adelante.
Dibujos lineales. Por favor envíe impresiones de buena calidad. Las inscripciones deben ser claramente legibles. El mínimo grosor de línea será de 0,2 mm en relación con el tamaño final. En el caso de Ilustraciones en tonos medios (escala de grises): Envíe por favor las impresones bien contrastadas. La ampliación se debe indicar mediante barras de escala. Se aceptan figuras en color.

Tamaño de las figuras
Las figuras deben ajustarse a la anchura de la columna (8.5 centímetros) o tener 17.5 centímetros de ancho. La longitud máxima es de 23 centímetros. Diseñe sus ilustraciones pensando en el tamaño final, procurando no dejar grandes espacios en blanco. Todas las tablas y figuras deberán ir acompañadas de una leyenda. Las leyendas deben consistir en explicaciones breves, suficientes para la comprensión de las ilustraciones por si mismas. En las mismas se incluirá una explicación de cada una de las abreviaturas incluidas en la figura o tabla. Las leyendas se deben incluir al final del texto, tras las referencias bibliográficas y deben estar identificadas (ej: Tabla 1 Características...). Los mapas incluirán siempre el Norte, la latitud y la longitud.

Preparación del manuscrito para su envío

Texto
Grave su archivo de texto en un formato compatible con Microsoft Word.

Tablas y Figuras
Cada tabla y figura se guardará en un archivo distinto con número da tabla y/o figura. Los formatos preferidos para los gráficos son: Para los vectores, formato EPS, exportados desde el programa de dibujo empleado (en todo caso, incluirán una cabecera de la figura en formato TIFF) y para las ilustraciones en tonos de grises o fotografías, formato TIFF, sin comprimir con una resolución mínima de 300 ppp. En caso de enviar los gráficos en sus archivos originales (Excel, Corel Draw, Adobe Ilustrator, etc.) estos se acompañaran de las fuentes utilizadas. El nombre de archivo de la figura (un archivo diferente por cada figura) incluirá el número de la ilustración. En ningún caso se incluirá en el archivo de la tabla o figura la leyenda, que debe figurar correctamente identificada al final del texto. El material gráfico escaneado deberá atenerse a los siguientes parámetros: Dibujos de lineas: el escaneado se realizará en linea o mapa de bits (nunca escala de grises) con una resolución mínima de 800 ppp y recomendada de entre 1200 y 1600 ppp. Figuras de medios tonos y fotografías: se escanearan en escala de grises con una resolución mínima de 300 ppp y recomendada entre 600 y 1200 ppp.

Recepción del manuscrito
Los autores enviarán un original y dos copias del artículo completo al comité editorial junto con una copia digital, acompañados de una carta de presentación en la que ademas de los datos del autor, figuren su dirección de correo electrónico y su número de fax, a la siguiente dirección:

IBADER
Comité Editorial da revista Recursos Rurais
Universidade de Santiago.
Campus Universitario s/n
E-27002 LUGO - Spain

Enviar el texto y cada una de las ilustraciones en archivos diferentes, en alguno de los siguientes soportes: CD-ROM o DVD para Windows, que irán convenientemente rotulados indicando su contenido. Los nomes de los archivos no superarán los 8 caracteres y no incluirán acentos o caracteres especiales.El archivo de texto se denominará por el nombre del autor.

O bien enviar una copia digital de los archivos convenientemente preparados la dirección de e-mail:
ibader@.usc.es

Con los archivos incluya siempre información sobre el sistema operativo, el procesador de texto, así como sobre los programas de dibujo empleados en las figuras.

Diciembre 2015

Recursos Rurais

Revista do Instituto de Biodiversidade Agraria e Desenvolvemento Rural (IBADER)

Selection process and manuscript evaluation

The articles, reviews and notes must be original, and will be previously evaluated by the Editorial Board and the Scientific Advisory Committee. Manuscripts submitted to Recursos Rurais will be subject to confidential review by two experts appointed by the Editorial Committee, which may also consider choosing reviewers suggested by the author. In cases of dispute the intervention of a third evaluator will be required. Finally it is for the Editorial Committee's decision on acceptance of work. In cases in which the reviewers suggest modifications to the submitted text, it will be the responsibility of the Editorial Team to inform the authors of the suggested modifications and to oversee the revision process. In cases in which the submitted manuscript is not accepted for publication, it will be returned to the authors together with the reviewers'comments. Please note that any manuscript that does not adhere strictly to the instructions detailed in what follows will be returned to the authors for correction before being sent out for review.

Instructions to authors

Editorial procedure

Recursos Rurais will consider for publication original research articles, notes and reviews relating to research and technological developments in the area of sustainable development of natural resources in the rural and conservation areas contexts, in the fields of conservation, biodiversity and environmental management, management of agricultural, livestock and forestry production systems, and land-use planning.

Manuscript preparation

General remarks

Articles may be submitted in Galician, Spanish, Portuguese, French or English.

Manuscripts should be typed on A4 paper, and should not exceed 15 pages including tables, figures and the references list. All pages should be numbered (though references to page numbers should not be included in the text). The manuscript should be written with Microsoft Word or a Word-compatible program, on one side of each sheet, with double line-spacing, 2.5 cm margins on the left and right sides, Arial font or similar, and font size 11. Neither tabs nor indents should be used, in either the text or the references list. Paragraphs should not be separated by blank lines.

Species and genus names should be written in italics. Genus names may be abbreviated (e.g. Q. robur for Quercus robur), but must be written in full at first mention. SI (Système International) units should be used. Technical nomenclatures and style should follow the most recent edition of the CBE (Council of Biology Editors) Style Manual.

Title page

The title page should include a concise and informative title (in the language of the text and in English), the name(s) of the author(s), the institutional affiliation and address of each author, and the e-mail address, telephone number, fax number, and postal address of the author for correspondence.

Abstract

Each article should be preceded by an abstract of no more than 200 words, summarizing the most important results and conclusions. In the case of articles not written in English, the authors should supply two abstracts, one in the language of the text, the other in English.

Key words

Five key words, not included in the title, should be listed after the Abstract.

Article structure

This should where possible be as follows: Introduction, Material and Methods, Results and Discussion, Acknowledgements, References. Section headings should be written in bold with font size 12. If subsection headings are required, these should be written in italics with font size 11, and should not be numbered.

Introduction

This section should briefly review the relevant literature and clearly state the aims of the study.

Material and Methods

This section should be brief, but should provide sufficient information to allow replication of the study's procedures.

Results and Discussion

This section should present the results obtained as clearly and concisely as possible, where appropriate in the form of tables and/or figures. Very large tables should be avoided. Data in tables should not repeat data in figures, and vice versa. The discussion should consist of interpretation of the results and of their significance in relation to previous studies. A short conclusion subsection may be included if the authors consider this helpful.

Acknowledgements

These should be as brief as possible. Grants and other funding should be recognized. The names of funding organizations should be written in full.

References

The references list should include only articles that are cited in the text, and which have been published or accepted for publication. Personal communications should be mentioned only in the text. The citation in the text should include both author and year. In the references list, articles should be ordered alphabetically by first author's name, then by date.

Examples of citation in the text:

Similar results have been obtained previously (Fernández 2005a, b; Rodrigo et al. 1992).

Andrade (1949) reported that...

According to Mario & Tineti (1989), the principal factors are...

Moore et al. (1991) suggest that...

Examples of listings in References:

Journal article:

Mahaney, W.M.M., Wardrop, D.H. & Brooks, P. (2005). Impacts of sedimentation and nitrogen enrichment on wetland plant community development. Plant Ecology. 175, 2: 227:243.

Book chapter:

Campbell, J.G. (1981). The use of Landsat MS ata for ecoloical mapping. In: Campbell J.G. (Ed.) Matching Remote Sensing Technologies and Their Applications. Remote Sensing Society, London.

Lowell, E.M. & Nelson, J. (2003). Structure and Morphology of Grasses. In: R.F. Barnes e al. (Eds.). Forages: An Introduction to Grassland Agriculture. Iowa State University Press. Vol. 1. 25-50.

Complete book:

Jensen, W. (1996). Remote Sensing of the Environment: An Erath Resource Perspective. Prentice-Hall, Inc., Saddle River, New Jersey.

Standard series:

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Electronic publications:

Collins, D.C. (2005). Scientific style and format. Available at: http://www.counckjnce.org/publications.cfm [5 January 2005]

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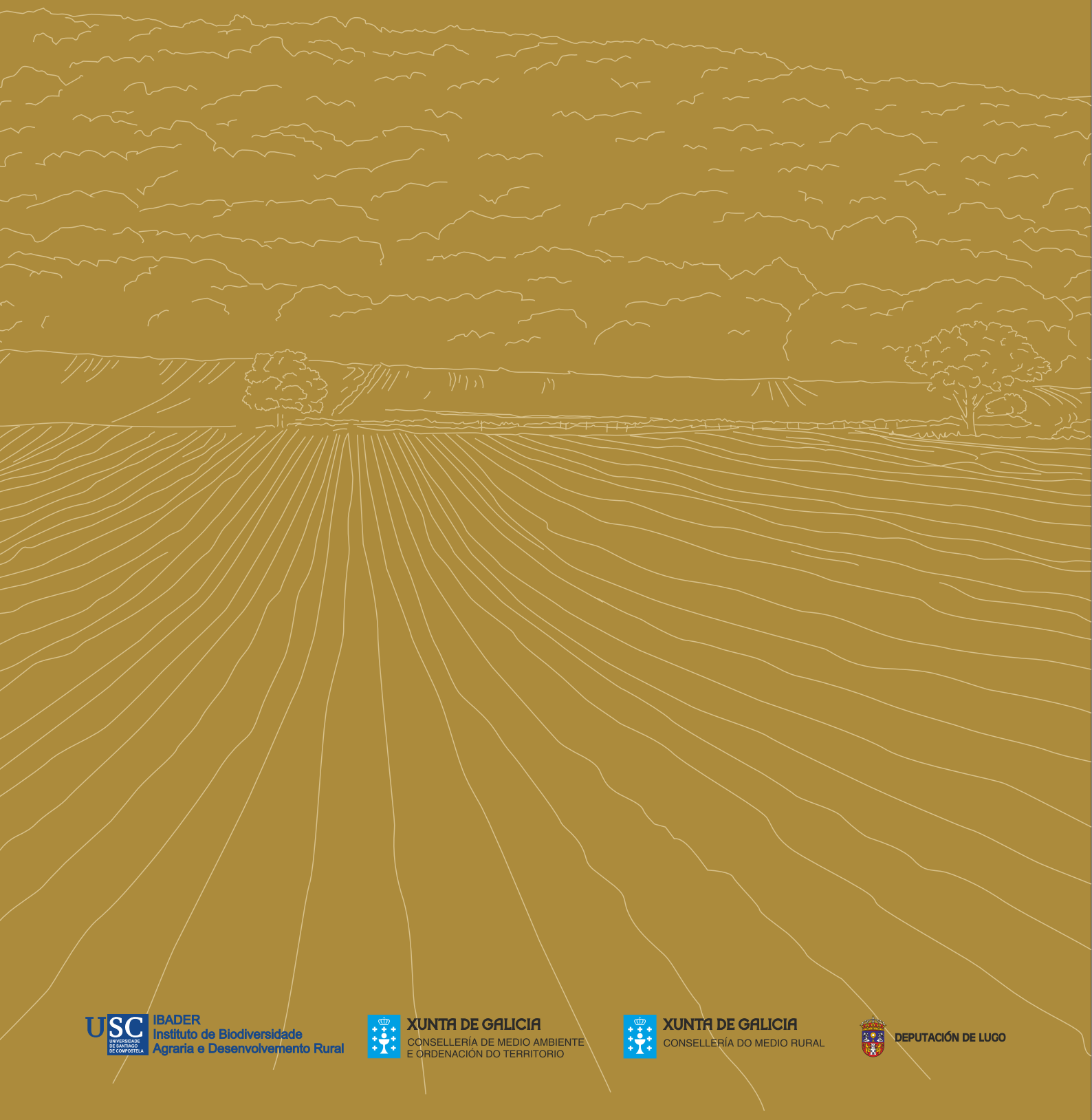

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