Università degli Studi di Milano

GRADUATE SCHOOL OF VETERINARY SCIENCES
FOR ANIMAL HEALTH AND FOOD SAFETY
Director: Prof. Valentino Bontempo

Doctoral Program in Animal Nutrition and Food Safety

Academic Year: 2012-2013

Strategies to optimize the productive performance of beef cattle

Riccardo Compiani

Tutor:

Prof. Vittorio Dell'Orto

Coordinator:

Prof. Giovanni Savoini

To my family

and friends

Index

CHAPTER 1

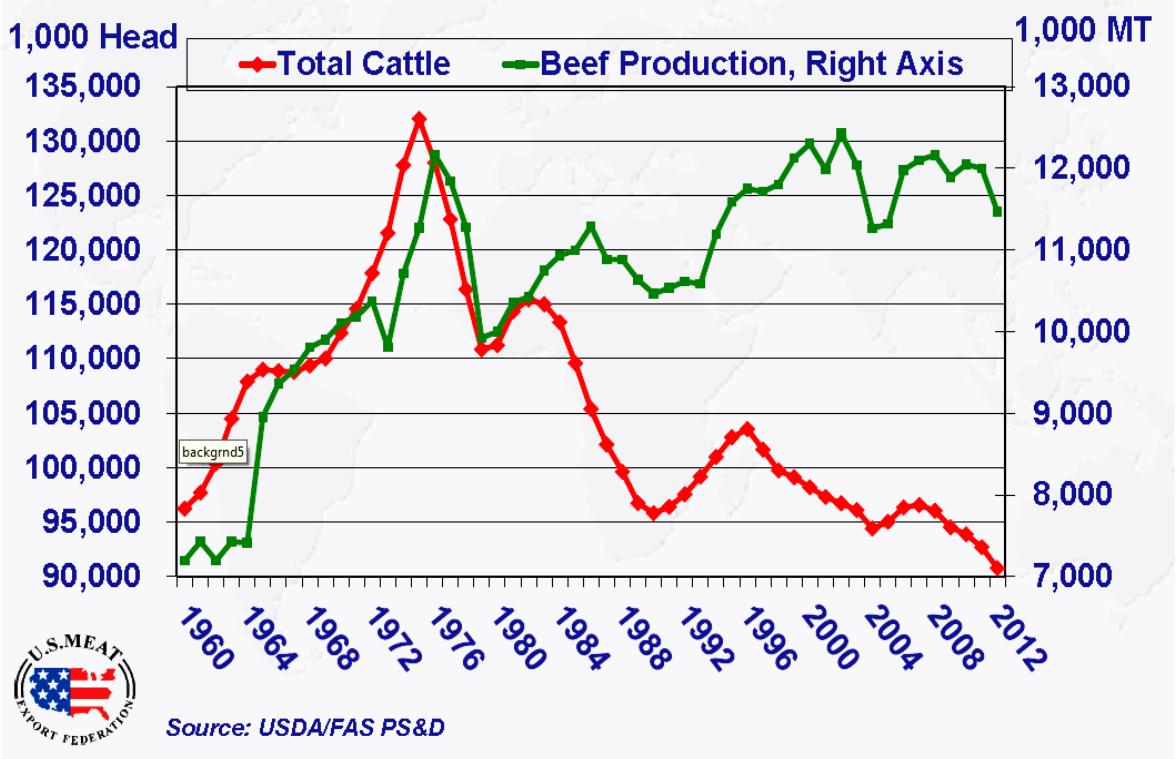
Foreword

1. Foreword

The optimization and the achievement of high level of efficiency are definitely two driving principles for human evolution. In fact, is just thank to the adaptation of his own body and abilities that man has evolved driven by the inherent need to improve his condition. Reach the efficiency means getting a better result by reducing most of the efforts and wastage in achieving it. This concept fits in any production system and therefore also in agriculture and livestock. The masterful example is the mechanization of agriculture after the World War II that in a very short time has led to a great increase in the productivity of each individual farm. Has been estimated that in 1940, a farm was on average able to produce food for 19 people, while in 1970 for 73 people.
Mechanization were later joined by other major innovations that helped in optimizing the production process such as genetic selection of cultivars and animals, the development of more effective drugs and vaccines, better techniques and technologies, etc. Even if not all of these strategies have led to the expected benefits, in 2010 it was estimated that a farm could feed an average of 158 people, incredible leap forward promoted by the optimization of the production process.
Even meat production system run over by this major wave of innovation, and the proof is clear from the graph in Figure 1. In the analysis carried out by the USDA, emerges that over the last 40 years, the American beef cattle population is characterized by an average decreasing trend. To this heard reduction, however, is associated a huge increase in the amount of meat produced, sign of a sharp increase in the productivity of the individual animal. Should take into account that the production system implemented in the US is slightly different from that of Europe in terms of type of housing and opportunities to use growth promoters. Despite these differences, the European trend of cattle and meat production is very similar proving that in the old continent happens an incredible and probably greater achievement of a high level of efficiency.
In recent years, the major need that pushes the increasingly optimization of the production process is certainly the reduction of the production cost due to the economic framework of the world. While this recession circumstance leads to more difficulties, on the other hand is inevitably promoting the onset of new opportunities that are leading to a significant improvement of farming

conditions and animal welfare, with positive impact on productivity and quality and safety of food products.

Figure 1. Beef cattle population and meat yield in the US.



In this scenario, scientific research has the responsibility to provide to the production sector more innovative and advanced tools. The research can provide in fact strategies and tools that, optimizing the production process, lead to the reduction of the production cost. Among the objectives that animate scientific research must unfortunately also enter the economic aspect which although may seems a not so deep and admirable intent, but acquires a fundamental value when is seen as a necessity to keep alive a sector and all the people employed in it.

1.1 Strategies to optimize the productive performance of beef cattle

The strategies to optimize the meat production process are mainly aimed at maximizing growth performance, reducing in this way the days on feed needed to achieve the slaughtering time. These strategies can be grouped into three

categories: develop a proper diet to the needs of different types of animals in the different stages of production as well as the objectives of the breeder, improve farm environment and, therefore, animal welfare, and improve animal health.

1.1.1 Tailored diet to requirements of any animal type in each rearing phase and to farm objectives

A proper diet is essential to promote the best growing performance together with optimal health. Diets should be formulated considering three main aspects: type of animal, rearing phase, target of farmer and market.

First of all is very important to know very well the characteristic of the animal reared. Beef breeds can be divided in two main categories: early and late fattening. Among the early fattening cattle are British breeds like angus, crossbreeds between beef and dairy but also, heifers of any breeds, with the exception of the double muscle breeds. Among these last breeds, the most important are Blonde D'Aquitaine, Belgian Blue, Piemontese and Gasconne. Among the late fattening normal muscle breed, the most important are Charolaise and Limousine but also other French breeds such as Aubrac and Salers. There are also many crossbreeds, which comes out with the aim to improve growth performance, such as Charolaise per Salers crossbreed, or to avoid dystocia at calving such as Limousine male per Charolaise heifer crossbreed, which are normally called "blonds". Among this category, are also some famous Italian breeds but reared almost exclusively in Italy. Nutritional approaches shall be chosen considering the different ability of each animal to get fat, in association, of course, with the purpose of the farmer. In early fattening breeds, fattening deposition starts very early, so diet should be adequate in starch content, should be characterized by a good protein level to maximize myogenesis and without fat supplementation. Instead, in late fattening breeds, there is a long time lag between the maximum development of muscle and the maximum adipose tissue deposition. In these animals, the daily gain remains high until the later stages of rearing and it's often necessary to supplement diet with by-pass fat to achieve optimum fat cover. In double muscle breeds and in early fattening breeds with normal muscle mass, the addition of fats, as well as very high levels of starch since the early rearing stages, is essential if are slaughtered at lighter weights.

Diet shall also be formulated considering the animal requirements in relation to rearing phase. The first phase, the adaptation after the arrival in the fattening

unit is the most critical stage due to the high stress and morbidity. Is thus necessary to limit the energy content and keep in mind the target to promote a quickly recover of rumen functionality, reduced by stress, fasting and water deprivation. Arrival diet have to contain highly degradable and physical effective NDF, protein concentration must not exceed 13%, while energy concentration must be no more than 0.90 UFV/kg DM. Studies underline that values above this threshold during adaptation phase are highly correlated with an increasing of BRD morbidity and severity (Lofgree, 1983; Galyean et al., 1999). Arrival diet should be administered for the entire risky period, that normally is 15-20 days after arrival.

During fattening and finishing phases, animals are generally fed with very high energy diets, mainly provided by fermentable carbohydrates. Could happens that beef cattle pass in a very short time from an adaptation diet with low energy and high effective fibre concentration, to a diet much more fermentable. In order to limit digestive disorder, but also to maximize digestive efficiency, the transition between arrival to fattening diet must be very gradual. A good practice is to provide at least 3 diets: one for the adaptation phase, one for the finishing phase and one intermediate between these two. Is also possible to obtain 5 diets, administering, during the transition between two diets, part of the less energetic diet in the morning and part of the more energetic one in the afternoon.

The animal requirements in relation to rearing phase also concern minerals and vitamins. In stressful situations in fact, micronutrients requirements are higher than in normal conditions because of the greater immune system stress, the major kidney losses and the lower minerals and vitamins intake due to the lower feed consumption and rumen functionality. Group B vitamins, vitamin K and C are synthesized by ruminal microflora and in case of low ruminal pH, frequently in high energy diets, happens a reduction of rumen synthesis of these vitamins, first of all the thiamine (B1). In intensive beef cattle rearing, fed with high energy diets and undergone high stressors, is still advisable to supplement these vitamins and not only those not synthesized such as vitamins A, D and E. In fact are very infrequent the situation of vitamins excess, but more frequently are the events of deficient vitamins supplementation.

In the end, diets should also be formulated considering farmer target and possibility. The nutritive level of the fattening diet should be modulate according to fattening cover that the farmer is asked to produce by the market. Another possibility is reduce the energy level or improve it in order to lengthen or

shorten the rearing period to sell the animal at the slaughterhouse in the best period. This strategy, should be applied in a very careful way since does not always lead to a real economic advantage. The feed to conversion rate of beef cattle increases in an uneconomical way with the progress of growth and, in particular, when the peak of the development of muscle tissue follows that of the adipose tissue. The development of these tissues is characterized in cattle, as in humans, by trends and peaks very different in relation to breed and sex as already described above. Considering these characteristics, therefore, the speed with which a tissue develops, reaches its peak and then slows down, is definitely very different and must be carefully considered in order not to drastically affect production efficiency. In fact after reach the pick, to maintain the growth is required a greater expenditure of energy and nutrients.

In Table 1 are reported the growth performance of males beef cattle of French breeds. At a slaughtering weight over 640 kg occurs a significant decrease of the average daily weight gain and feed conversion, that becomes even dramatic when is over 790 kg. In such situations, due to the significant reduction of animal's ability to convert feed into muscle mass, this approach is economically disastrous.

Table 1. Growth performance of French breed beef cattle (Jurie et al., 2005)

Live weight at slaughtering	**641 kg**	**794 kg**	**952 kg**
ADG, kg/day	1.59	1.19	1.04
G of growth/energy unit assumed	194	142	102

Another example is reported in Table 2. The average individual weight highlights an ADG of 1.8 kg/day until 700 kg but then decreases to 0.9 kg/day during the last 50 days of fattening until the average slaughtering weight of 750 kg.

According with these findings, diets should be formulate in order to promote the maximum growth when the growth efficiency of cattle is the best. Every week of delay in slaughter corresponds to an economic loss for the farmer. This target can be achieved only in those situation characterized by a very good farm environment and management. In fact, those animals fed with high nutritive level diets to fully exploit their potential, are in a considerable more risky situation and can fall into health problems if are not in a very comfortable farm environment or in case of wrong operating procedures.

Table 2. Growth performance of Charolaise male beef cattle (Sgoifo Rossi et al., 2013).

Weight			ADG		
d_0	d_{112}	d_{162}	0-112	112-162	0-162
509	721	755	1,86	0,67	**1,49**
519	701	733	1,60	0,63	**1,30**
492	715	763	1,96	0,94	**1,64**
490	723	772	2,04	0,96	**1,71**
492	679	751	1,64	1,41	**1,57**
544	722	780	1,56	1,18	**1,45**
488	675	735	1,64	1,18	**1,50**
521	710	753	1,66	0,84	**1,41**
530	766	806	2,07	0,78	**1,67**
517	698	740	1,59	0,93	**1,40**
447	736	782	2,16	0,90	**1,81**
467	701	767	1,75	1,29	**1,62**
492	757	780	1,98	0,45	**1,56**
462	682	706	1,64	0,47	**1,32**
436	678	739	1,81	1,20	**1,64**
445	716	736	2,02	0,39	**1,57**
451	683	735	1,74	1,02	**1,54**
491	682	736	1,44	1,06	**1,33**
445	705	728	1,95	0,45	**1,54**
458,80	**486,21**	**1,80**	**707,89**	**752,47**	**0,88**

1.1.2 Farm environment and animal welfare

As will be described in the next chapters, rearing environment play a key role in promoting or limiting the onset of diseases affecting growth performance. In addition to the negative effect on feed intake given by fever and pain, typically of pathological condition, even the simple poor environmental comfort can strongly limit growth. Hereinafter are reported some example of consequence of situations characterized by poor welfare attention.

The incidence of lame cattle increases when there is not enough space in feed bunk (Murphy et al., 1987). In this situation, animal could even show abnormal behavior and worse feed to conversion rate (Kongaard, 1983; Lutz et al., 1982; Hanekamp et al., 1990). In case of 75 cm of space in the feed bunk for each cattle, growth and feed consumption are better than in case of 55 cm/herd

(Hanekamp et al., 1990. Regarding, is also very important how feed bunk and feed rack is designed (Bouissou and Signoret, 1971).
In case of little space available in pen on slatted floor, tail lesions increase (Konggard et al., 1984; Madsen, 1987; Madsen et al., 1987; Andersen et al., 1997). Space and volume of air availability are strictly related to BRD morbidity and mortality as reported in Tables 3 and 4 (Béranger, 1982).

Table 3. Effect of volume of air on BRD mortality in beef cattle reared in straw litter.

Volume of air exchange (m^3/head)	n° of cattle	Mortality (%)
10 - 15	1014	1,35
15 - 20	1465	1,29
20 - 25	663	0,7
>20	1765	0,65

Table 4. Effect of space available on BRD mortality in beef cattle reared in straw litter.

Space available (m^2/head)	n° of cattle	Mortality (%)
< 2,5	2124	1,98
2,5 - 3	1717	1,08
3 - 3,5	1467	0,53
> 3,5	1796	0,55

Has been reported by several authors that voluntary feed consumption increases when cattle have more space availability (Mossberg et al., 1992; Pahl, 1997; Fisher et al., 1997; Andersen et al., 1997; Ruis-Heutinck et al., 1999). In case of little space availability, happens a reduction of ADG not only because of the low feed intake but even for a worsening in feed to conversion rate due to high energy consumption since cattle spend too much time standing (Fisher et al., 1997).
Even pen's floor surface is very important, indeed, beef cattle reared on slatted floor show less resting time during the day (6-12 times per 24 h) respect to those on straw litter (15-25 times per 24 h) and also tend to lay on the same side much longer without changing position leading to tissue damage (Ladewig, 1987). Some authors found out that improving slatted floor with rubber can reduce disturbances in lie down, get up, and slipping (Wee et al., 1989; Koberg et al., 1989; Smits, 1993).

1.1.3 Improvement of animal health

A correct nutrition and a good farm environment are very often not enough to avoid any possible health problem in the herd. Because of certain characteristics of the rearing system reported below, animals are exposed to several stressful conditions able to reduce immune system and ruminal activity. Other than infective pathogens, even those normally presents, for example in the upper air ways, could lead to severe diseases. The objective of a good farm management aimed to prevent morbidity and mortality with the awareness that an healthy animal can have a better growth, shall take into account another couple of key points. First of all, is very important to address the risks, in this case which are the possible health problems the cattle can fall on, in relation to their characteristics and rearing phase. Indeed, only knowing the possible triggering and risk factors is possible to plan correct prevention strategies intended not only as specific vaccination protocols but even changes in some operating procedures. The second important thing that will be discussed afterwards, is to promote animal's quickly recover of ruminal activity other than improve their immunity.

1.2 Main health problems of beef cattle

1.2.1 Stress and adaptation

Beef cattle rearing is mainly based on newly arrived animals coming from graze, and in particular in Italy, those animals arrive from abroad, mainly from France. This implies some crucial factors such as transport, feed and water restriction, mixing, new social and environmental interactions. These factors are stressful and can affect the immune system and general animals health. The adaptation to new environment and social conditions gives rise to stress conditions and driving to severe physiologic and psychological reactions that compromise health. This is the reason because the adaptation phase for newly arrived cattle is the most important critical point.

Discomfort situation in which animals are involved not only during transport but even before and after it, are very important in increasing morbidity in particular due to respiratory diseases. Before travel, cattle are often recently weaned and, at arrival in commercial market, are grouped together in gathering barns, with important stressing factors like: handling, mixing different groups of animals mutually unknown, crowding in narrow spaces, diet variations or feed

and water deprivation. Also, in these barns, there is a continuous turn-over of animals that increases the environment pathogens level.

During transport, animals are subjected to different stress conditions as water and feed restriction, fear from sudden movement during transport, noise, adverse climatic conditions, restricted spaces and low comfort, competition with other animals. Transport length can influence the severity of stress, because adverse conditions interact with animals for a longer time. So, cattle imported from very far farms have worse immune defence than those moved from near farm.

After transport, animals are exposed again to different stressful events, like interaction with humans, treatments, nutritional adaptation, social interactions, new housing type and weather conditions. For this reason, immediately after arrival to fattening facilities, farmer have to starts to managed correctly all the risk factors to avoid high morbidity.

Stress is a biological response to a stimulus that perturbs the subject homeostasis. Broom in the '80 indicates that this situation comes true every time a subject is put through adverse or dangerous situations. The response is behavioural, psychological and physiological. Several authors describe the welfare condition like a status of total health, both psychological and physical, in which the animal is harmonized with the environment.

Among psychological stressful events we have: weaning, grouping, competition and being in new situations and experiences. As already mentioned, physical stress are water and feed restriction, weakness, environmental and climatic adverse factors and injuries. The entity of the reactions depends not only by the seriousness of stressing factors, but also by some subjective characteristics like breed, sex, weight, age and temperament, and by some other factors like previous contact with similar situations.

After stress and panic situation, the organism reacts with a secretion of epinephrine and norepinephrine. In this situation there is a modification of the hypothalamus-hypophysis-adrenal gland line, with the consequent secretion of glucocorticoids. It is demonstrated that the immune response is influenced by these hormonal mechanisms. In events of acute stress, animals have a "fight and escape" reaction with secretion of catecholamine and activation of the sympathetic nervous system. There is an increase in heart rate, systolic pressure and perfusion of several districts. Besides all this systemic reactions, there is also a reduction in the immune defence by secretion of adrenaline and noradrenaline.

Other than immunodeficiency, the stressful related metabolic status of newly received beef cattle, induces a reduction of ruminal motility, alteration in nutrients intestinal absorption, increase of nutritional need, associated with an increase of minerals kidney excretion.
The impairment of animals health and growth performance during the adaptation phase, is more severe as farmer management skills and attention to welfare are lower. In this regard has been evidenced that with an adequate management, the stressing event could be reduced drastically, improving both animal health and performance.

1.2.2 Bovine respiratory disease

Bovine respiratory disease (BRD) is the main health problem in the beef cattle industry worldwide and has serious animal welfare impact and economic loss (Schneider et al., 2009; Panciera and Confer, 2010; Fucci et al., 2012). This multifactorial disease is closely related to the predisposing factors which include the immune status of young cattle, severity of stressful events, environmental characteristics, facilities, and previous health management (Panciera and Confer, 2010).
The Italian beef system is based on fattening young calves imported from abroad, especially from France. Cattle are inevitably subject to stressful transport conditions which last on average 8-12 hours. To meet customer demand, imported animals are more often females, very young and light weight. These animals may not be fully immune-competent, and therefore more susceptible to develop BRD. The economic impact of BRD is not only related to the cost for drugs to treat sick animals, but even to the possible high mortality and to the lack of growth of recovered cattle. This negative impact of BRD on animal growth is mainly due to their lower feed intake induced by fever; indeed, two studies showed that animals suffering from respiratory disease visited the feed bunk less often and spent less time at the bunk (Sowell et al. 1999; Buhman et al., 2000). However, in the days after recovery, animals went to the feed bunk more often than animals which were never treated. In some circumstances, this behaviour results in a compensatory growth which allows previously morbid calves to fill the growth gap (Jim et al., 1993; Babcock et al., 2009). Nevertheless, compensatory growth does not always occur and it is strongly influenced by animal age and weight and by the length of restriction and length of the finishing period. Indeed, lighter animals (220-270 kg) seem to be less affected by the

negative effects of BRD on ADG probably because they can take advantage of a longer finishing time to fill the growth gap (Babcock et al., 2009; Holland et al., 2010). Data available in the literature concerning the compensatory growth after the pathological event are discordant even also for the impact that BRD has on carcass traits. Studies report that carcasses of cattle incurred in respiratory disease lighter and leaner (Roeber et al., 2001; Larson, 2005; Schneider et al., 2009; Garcia et al., 2010) with a reduction of even 26.5% of fat cover thickness at the level of the twelfth rib. Moreover, fat cover thickness of chronic animals could be reduced till 43.4% and the carcass weight is reduced by 5% for each relapse event (Gardner et al., 1999). Recent human medicine acquisitions developed on mice and pigs models showed that pathological states affect growth and some carcass characteristics because of an hepatic increased needs of amino acids and in particular of those aromatic (phenylalanine, tyrosine and tryptophan) essential for acute phase proteins production. Specific inflammatory mediators, such as TNF-α, IL-1 and LPS are able to promote anorexia and insulin resistance and induce muscle atrophy by activating the transcription factor NF-kB promoter of muscle protein catabolism (Reeds et al. 1994; Kimball and Jefferson, 2006; Acharyya et al., 2007; Gifford et al., 2012). Additionally NF-kB is able to prevent myoblasts differentiation interfering with muscle regeneration after a chronic disease (Mourkioti et al., 2006). Considering this last finding, the muscle atrophy should increase proportionally with the severity and duration of inflammatory process, explaining why chronic animals incurred in BRD several times, present lack of growth and worse carcass traits compared to healthy animals although with a better feed to conversion rate after symptoms recovering.

In order to avoid, or better, to limit the consequences of BRD on animal growth performance and then on farm economic balance, is essential to plan and to apply prevention strategies. The three strategic pillars of BRD prevention in beef cattle rearing are risk factors management, good vaccination prophylaxis protocols and very early detection of sick animals, treating them with effective drugs. About the first pillar, only through a case by case careful and detailed evaluation of animal at arrival, together with the assessment of the fattening unit, can lead to the achievement of all the objective. The risk assessment is fundamental to plan and apply all the possible preventive strategies in order to reduce mortality and morbidity. Thanks to the reduction of health problems, animal will certainly growth better and faster. The reduction of treatments need

satisfies not only the farmer reducing its productive cost, but is also a positive situation that meets the demands of regulatory system and the ethics of consumers.

From a scientific and from a practical point of view, a lot of work has been done instead regarding individual treatments even if the early detection remains still a problem that probably needs some technological further helps. In the last years, in fact the scientific research focused the attention on technological devices for the early fever detection. Fever seems to appear from two to nine days before other symptoms such as nasal discharge, abnormal breath activity, depression and anorexia that allow the veterinarian to identify the problem and perform the therapy. The tested devices, as fever ear tags, ruminal temperature bolus, infrared thermography, GPS trackers, pedometers and accelerometers to evaluate changes in physical activity and devices to detect changes in feeding behavior, are currently characterized by low specificity if considered individually but are producing interesting and promising results (Schaefer et al., 2007, 2012; Timsit et al., 2001a, 2011b).

Timing in individual treatment is essential. In fact, only a treatment performed at the onset of early symptoms allows to control bacterial replication and the effects of bacteria and toxins on lung tissue. In case of late treatment, necrosis and suppuration can limit gases exchange and the diffusion of antibiotic in the infected area, leading to an irreversible lung damage. Metaphylaxis antibiotic treatment, administered at the early stage of bacterial proliferation in the upper respiratory tract, lead to a reduction of bacteria inhaled into the lungs or transmitted from cattle to cattle. The result of the metaphylaxis approach done with effective drugs, is an important reduction of morbidity and mortality. Metaphylaxis is a common prevention strategies performed at the arrival of those groups of young cattle considered at high BRD risk, with the aim of reducing the negative effects of respiratory disease on welfare and growing performance (Nickell and White, 2010).

1.2.3 Locomotor apparatus diseases

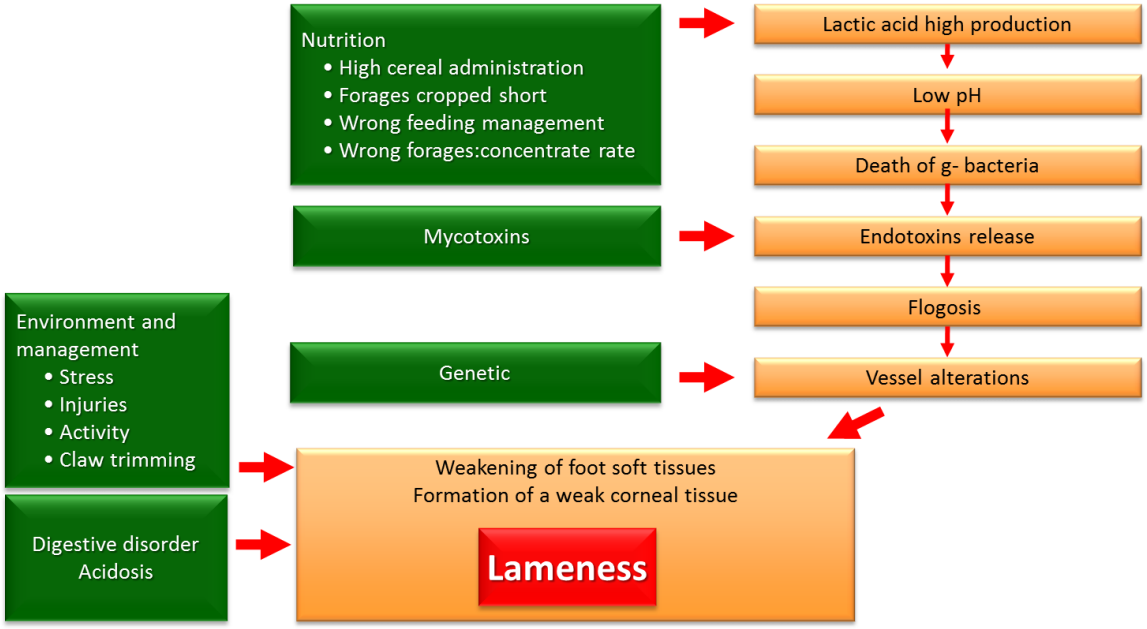
Lameness is the second main health problem in beef cattle rearing, able to seriously affect not only animal's health and welfare, but also the production system profitability. Lots of researches are conducted in dairy not only because locomotor apparatus diseases can reduce milk production but also because negatively affect cows fertility. Probably due to a less immediate response of

locomotor apparatus diseases negative effects, are very little the information about morbidity, risk factors and performance consequences in beef cattle, especially in Europe. In United States feedlot, where there is more interest in studying this issue, the economic losses due to locomotor apparatus diseases are well quantified, and include costs for therapies and laboratory analysis, reduction of weight gain, early culling and in the most severe cases, death of animals. The possible pathologies that can affect beef cattle locomotor apparatus are many, as many are the possible etiological agents, risk factors and tissues involved. Indeed, lameness can be due to a problem related to joints, bones, muscles or claw's soft or horny tissues. About it, foot diseases are reported as responsible of nearly 90% of lameness in dairy and approximately 70% in beef cattle. Surveys conducted in North America, show that locomotor apparatus diseases incidence is between 16 and 22% of total morbidity (Church and Radostits, 1981, Edwards, 1984; Griffin et al., 1993).

Locomotor apparatus diseases in beef cattle seem to be mainly on nutritional base (Figure 2). That is because normally beef cattle receive diets characterized by high nutritional level and high quantity of fermentable carbohydrates, which can lead to acidosis and, therefore, to laminitis. But there are many factors that may predispose to locomotor apparatus diseases or complicate the clinical findings, including sex, breed, weight, season, housing type, quality of management, mycotoxins, genetic or environmental condition, that lead to flogosis activation process at foot level. The vessel dysfunction, promote weakening of foot soft tissues, and formation of a weak corneal tissue and then lameness.

The high incidence of lameness, makes it one of the main issues concerning cattle welfare. Foot pathology are one of the most painful diseases that affect cattle, and are more common than other extremely painful syndromes, such as renal colic or abomasal displacement. Is not known how serious is foot pain in cattle, but it is assumed that in this species, foot nociception is similar to humans because at this level there is a dense network of sensory fibers and a large number of nerve terminals, particularly at heel level. Animals affected by foot pain show several postural changes and anomalies in locomotion, which tend to be more evident the greater the severity of lameness. Furthermore, a chronic painful condition leads to a reduction of feed intake and performances, a weakening of heart and lungs activity and increases nervousness and associated diseases (Whay, 2009).

Figure 2. Lameness etiopathogenesis.



This PhD dissertation will not focus directly on others health problems of beef cattle. BRD and LAD are the two major diseases complex in this sector but cattle can be affected by several other problems like parasitosis, urolithiasis, enterotoxaemia, and, of course, acidosis and related digestive disorders. Acidosis will be addressed however, in chapters 4 and 6, since it is an important triggering factor in lameness etiopathogenesis and in reducing growing performance.

1.3 European regulatory framework

Promote animal health is not only an ethical or economical issue but is also a request by the actual and future law regulation. The key aspect at the base of the recent law regulations are the reduction of antibiotics administration and animal welfare.

1.3.1 Reduction and responsible use of antibiotics

The problem of antibiotics use is clearly summarized in the opening lines of the introduction to the *Handbook of bio-safety and correct and rational use of antibiotics in livestock*, released by the Italian Ministry of Health in 2012: "Since the 50's till today, antibiotics in the veterinary medicine, represent a fundamental tool for the control of infectious diseases. Their introduction has led to the improvement of animal welfare and are an important tool to ensure the production of safety

food. Seventy years later, these applications are challenged by the emergence of antibiotic resistance".

Therefore, antibiotics are an effective tool in controlling animal health but their use should be careful and focused, otherwise seems to lead to the onset of resistance ability by microorganisms, nullifying subsequent treatments in the herd. Although for each drug are well calculated withdrawal periods between the end of therapy and the possibility of sending products of animal origin to human consumption, prolonged exposure to infinitesimal concentrations of residues in food is considered as a predisposing factor to the onset of antibiotic resistance in human medicine or other issues relating to public health such as acute toxicity, hypersensitivity, onset of cancer or metabolic disorders and digestive problems.

Currently, one certain thing is that antibiotic resistance is one of the major threats to public health in the European Union and the main cause of resistance to antibiotics in humans is the use of these antibiotics in human medicine, as stated by the coordinator of the "Antimicrobial Resistance and Healthcare Associated Infections" of the European Centre for Disease Prevention and Control (ECDC). However, scientific research is still investigating and monitoring any possible implication but in the meantime, for the precautionary principle, the governances have long been directed towards the reduction of use of antibiotics in livestock.

1.3.2 Ban of hormones and growth promoters

The first masterful example in regards of the reduction of drugs use in livestock production is the Directive 1831-2003 that prohibits the use of antibiotics and hormones not for therapeutic purposes but as growth promoters. Ionophore antibiotics in ruminant feed are able to reduce energetic and protein losses that characterize the ruminants digestion. In the beginning, that law was perceived as an unjust imposition that would cause incredible negative consequences in the economic balance of certain livestock activities. Instead, it was then revealed an opportunity. Surely after a first phase of discomfort due to the increase of some health problems such as necrotic enteritis in poultry or colitis in pigs, due to improved farming techniques many of that problems have been overcome with remarkable positive results. First of all, happens a reduction of cost related to medications (40-70% of antibiotics less in these production systems). In addition to that, is actually a quite widespread thought that thanks to environmental

comfort and good management practices and nutrition, can be greatly reduced morbidity in each production system.

1.3.3 Welfare

Animals are considered as sentient creatures, that are sensitive, able to feel sensations, and are not only as an instrument for the farm income (Treaty of Amsterdam, 1997). Several authors tried to give a definition to the term welfare and today the most appropriate one is probably that provided by Broom (1986), which defines animal welfare as "its state as regards its attempts to cope with its environment". This definition introduces the importance of the individual, pointing out that the concept of welfare may not be univocal but rather is a condition inherent to the animal. Who is able to adapt himself to the environment is in a state of welfare, on the contrary, the subject that can't, because of own psycho-physical characteristics or because of external factors, is in a condition of not welfare. The critical point is therefore to identify the condition that, regardless of the adaptive capacity of the individual, is able to certainly guarantee the welfare. From this point of view and considering that in certain circumstances animal fall on diseases when in discomfort condition, is clear how health and welfare are strictly linked.

Furthermore, consumers tend to associate animal welfare to safety and quality of food, identifying a low level of welfare with a negative impact on animal health. In this regard, a survey carried out in Europe (Kjaernes et al., 2009) shows that 87% of consumers consider important animal welfare while nearly 30% admit not to take into account this aspect while buying food. The same survey also shows how the consumer is still not very confident with the quality of meat and animal products in general. This finding highlights the importance of transfer, for example through labeling, all the work and the efforts done to ensure safety and quality obtained including animal welfare.

The issue of animal welfare is taken into careful consideration by the European Governance and not only for ethical aspects but also with the aim to satisfy the needs and consumer expectations in terms of safety and quality of products. At the base of which is undoubtedly the quality of animal life.

Based on these assumptions, the European Commission developed a series of laws regarding the welfare of animals in farm, during transport and at slaughter house. Specific laws regard calf (Directive 1991/629 and Directive 1997/02), pig (Directive 1991/630 and Directive 2001/88), laying hen (Directive 1988/166

and Directive 1999/74), and broiler (Directive 2007/43). In relation to adult cattle is ongoing a law draft by the committee of the European Council, called "Standing committee of the European convention for the protection of animal kept for farming purposes" which aims to define a legislation on the welfare of the entire sector of adult cattle (over 6 months). In all of these laws or draft are reported all the information regarding the farm characteristics and the operating procedures able to let the animal to adapt to environment. Very important thing is that to assess the welfare level of a farm, other than perform objective measurements, is very important to detect sign of poor welfare directly on the animal body and behavior. Indeed issues like skin lesions, fighting behavior but even BRD, lameness, bloat, diarrhea morbidity are important indicator of welfare.

1.4 Prevention

In order to develop appropriate prevention strategies is necessary to analyses the problems with a scientific and rational approach. With this aim should be a good idea to apply ways to manage problems typical of other productive sectors. The principles at the base of the risk management used in economics, corporations and governance can be partially adopted even in agriculture and livestock science since give a pattern of thought that can help a lot in managing the risk factors, as in this case, about animal health.

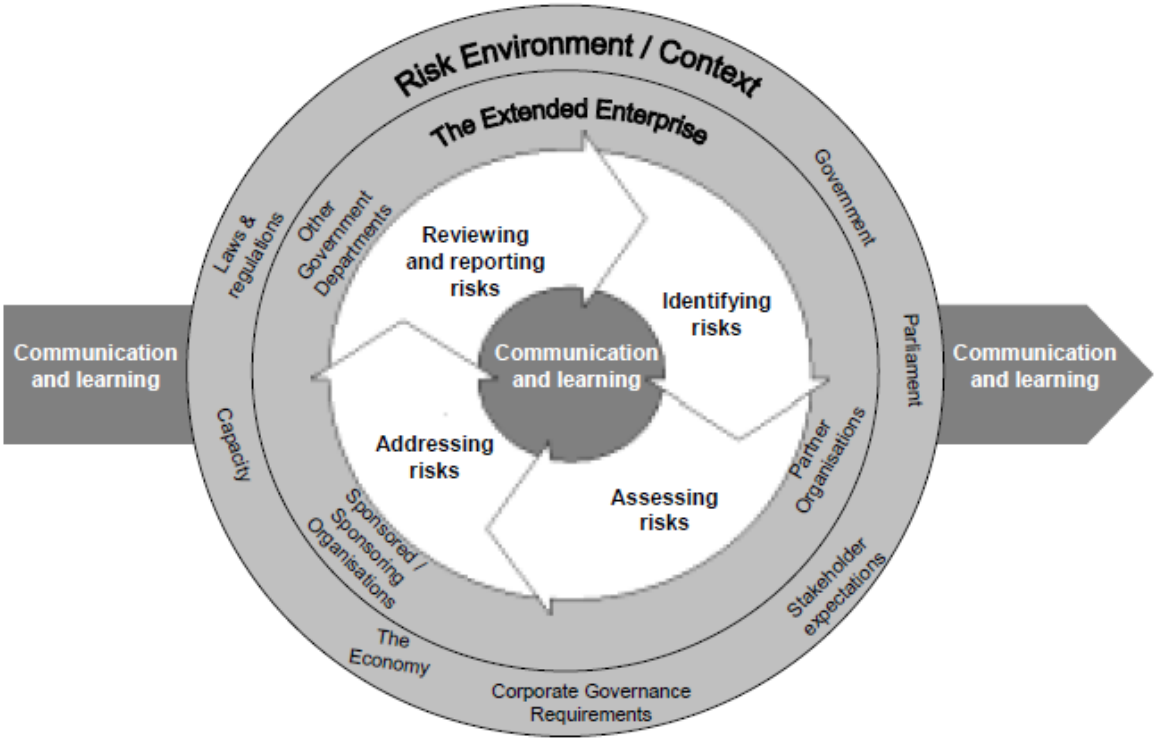
In recent years all economic sectors have focused the attention on risk management as the key to make organizations successful in delivering their objectives whilst protecting the interests of their stakeholders. Agriculture and livestock are two very important sectors of economy worldwide and certainly still more important in the next future due the increasing of world population and food demand. Is actually a need for these sectors to start to work in this way to growth together with others economical sector applying risk management protocol to improve efficiency, reducing wastage and then enhancing profitability.

The risk management is a several step doctrine that inevitable starts identifying the problem and the possible risk factors. Only after that can be made an evaluation and can be taken the correct decisions.

Below, are some of the key points for a correct risk management reported in "The Orange Book, Management of Risk - Principles and Concepts".

By definition, risk is uncertainty of outcome and a good risk management allows any organization, a farm in this specific circumstance, to have increased confidence in achieving its desired objective, effectively constrain threats to acceptable levels and take informed decisions about exploiting opportunities.
The risk has to be assessed in respect of the combination of the likelihood of something happening, and the impact which arises if it does actually happen. Risk management includes identifying and assessing risks and then responding to them. Risk is unavoidable, and every organization needs to take action to manage risk in a way which it can justify to a level which is tolerable.
The risk management strategy will be led from the top and embedded in the normal working routines and activities of the organization. All staff should be aware of the relevance of risk to the achievement of their objectives and training to support staff in risk management should be available.
The risk management is not a linear process; rather it is the balancing of a number of interwoven elements which interact with each other and which have to be in balance with each other. Furthermore, specific risks cannot be addressed in isolation from each other; the management of one risk may have an impact on another, or management actions which are effective in controlling more than one risk simultaneously may be achievable.
The model in Figure 3 illustrates how the core risk management process is not isolated but takes place in a context and how certain key inputs have to be given to the overall process in order to generate the outputs which will be desired from risk management.

Figure 3. Risk Management Model – developed from the model in the Strategy Unit's November 2002 report : "Risk – improving government's capability to handle risk and uncertainty".



1.4.1 Knowledge of problems, analysis of triggering and promoting factors

In order to manage risk, an organization needs to know what risks it faces, and to evaluate them. Identifying risks is the first step in building the organization's risk profile. Risks should be related to objectives since can only be assessed and prioritized in relation to them.

Starting from the goal of optimize beef cattle growing performance through the improvement of animal health, the first step for a correct specific disease risk management is to know deeply all the possible features related to that disease. The two main health problems in the intensive beef cattle rearing system are respiratory disease and lameness. In the chapter 4, will be deeply described the possible pathologies at the base of lameness onset, the risk factors related to the subjects and to the rearing environment. The scientific knowledge about this topic is very little, so the review of the risk factors reported in literature together with the experiences acquired in field situations are the first step for the further lameness risk assessment.

1.4.2 Risk assessment systems to plan preventive strategies

Regarding instead respiratory diseases in beef cattle, the knowledge about etiopathogenesis, triggering and risk factors is wider but the managing of BRD remains still difficult. The risk management of BRD can be considered at the second step respect to that of lameness. In this situation the risk has been identified and so has to be assessed and addressed. In chapter 3 will be presented a BRD risk assessment developed taking into account nearly all the possible risk factors that characterized the intensive beef cattle system in Italian fattening units. Regarding this topic, is necessary to develop some framework for assessing risks. The assessment should draw as much as possible on unbiased independent evidence and avoid confusing objective assessment of the risk with judgment about the acceptability of the risk.

The assessment needs to be done by evaluating both the likelihood of the risk being realized, and of the impact if the risk is realized. A categorization of high / medium / low risk in respect of each feature may be sufficient, but more detailed analytical scale may be appropriate as "5x5" matrices are often used, with impact on a scale of "insignificant /minor / moderate/ major / catastrophic".

The next step after assessing the risk is to address it. The purpose of addressing risks is to turn uncertainty to the organization's benefit by constraining threats and taking advantage of opportunities. There are five key aspects of addressing risk: tolerate, treat, transfer, take the opportunity and terminate.

Risk can be *tolerated* if negative effects are limited or the cost of taking any action may be disproportionate to the potential benefit gained. In other cases, risk can be *treated*. The purpose of treatment is that whilst continuing within the organization with the activity giving rise to the risk, action (control) is taken constrain the risk to an acceptable level. For some other risks, the best response may be to *transfer* them, but this specific action doesn't fit very well with the specific risk we are dealing with. This might be done by conventional insurance, or it might be done by paying a third party to take the risk in another way. Very often addressing risk brings to new opportunity. *Take the opportunity* is not an alternative to those above; rather it is an option which should be considered whenever tolerating, transferring or treating a risk. In the end, some risks will only be treatable, or containable to acceptable levels, by *terminating* the activity.

The option of "treat" in addressing risk can be further analyzed into four different types of controls: preventive, corrective, directive and detective.

Preventive controls are designed to limit the possibility of an undesirable outcome being realized. The more important is that an undesirable outcome should not arise, the more important it becomes to implement appropriate preventive controls. *Corrective controls* are designed to correct undesirable outcomes which have been realized. They provide a route of recourse to achieve some recovery against loss or damage. *Directive controls* are designed to ensure that a particular outcome is achieved. They are particularly important when it is critical that an undesirable event is avoided typically associated with Health and Safety or with security. *Detective controls* are designed to identify occasions of undesirable outcomes having been realized. Their effect is, by definition, "after the event" so they are only appropriate when it is possible to accept the loss or damage incurred.

1.4.3 Nutrition to promote immunity and to reduce the negative effects of stress

In a risk control approach, nutrition can play an important role. Considering the characteristics of the intensive beef cattle rearing, the main objective to achieve during the adaptation phase for first, but even during the fattening time, is to reduce any possible health problem. This can be achieve promoting as best we can the recovering of the ruminal activity after arrival and administering to the cattle all the possible natural and technological substances to fulfill not only their requirements related to their health condition, but even whatever that can help to improve their immune system. In this way the animal organism can react by itself to part of the environmental insults and pathogens.

After the adaptation phase in which the main target is to promote animal health, during the following rearing phase to that important goal joins the improvement of growing performance. In this phase, production efficiency should be pursued through different approaches. In this view, rumen fermentation represents one of the main critical points on which it's possible to implement interventions to improve cattle productivity. In fact the polygastrics establish an essential relationship with the microorganisms in their rumen, providing them with nutrients through which these microorganism proliferate, starting processes necessary to the ruminant itself, including the fiber degradation, the production of volatile fatty acids and the synthesis of bacterial proteins of high biological value and water-soluble vitamins. This synergy is, however, also characterized by a significant use of energy and nitrogen (Van Nevel and Demeyer, 1988). In fact, the rumen fermentation of carbohydrates and proteins are accompanied by the

loss of methane and nitrogen, respectively. The values stand between 8 and 12% for digestible energy ingested by ruminants lost in form of methane, and between 75 and 85% for nitrogen, which is excreted in feces and urine daily, and consequently cannot be used for the processes of bacterial protein synthesis (Tamminga 1992). These energy losses not only reduce the production performance but also contribute to the release of pollutants into the environment (Tamminga 1996). The experts in nutrition have long been working on an attempt to modulate the diverse populations of ruminal microorganisms with the goal of improving the energetic and protect efficiency in the rumen (Calsamiglia et al, 2006). This objective can be reached through a specific diet optimization, and by adding food additives that can modify the rumen environment, inhibiting or stimulating specific microbial populations.

The research has been therefore directed toward the identification of feed active principles for the modulation of rumen fermentation and to strength immune system, such as yeasts, organic acids, organic minerals, plant extracts, prebiotics and probiotics, paying particular attention to the products of natural origin in line with the expectations of the modern consumer (Calsamiglia et al, 2006).

1.5 References

Acharyya S., Villalta S.A., Bakkar N., Bupha-Intr T.B., Janssen P.M.L., Carathers M., Li Z.W., Beg A.A., Ghosh S., Sahenk Z., Weinstein M., Gardner K.L., Rafael-Fortney J.A., Karin M., Tidball J.G., Baldwin A.S., Guttridge D.C. (2007) Interplay of IKK/NF-κB signaling in macrophages and myofibers promotes muscle degeneration in Duchenne muscular dystrophy. *J. Clin. Invest.* vol. 117:889–901.

Andersen H.R., Jensen L.R., Munksgaard L., Ingvartsen K.L. (1997) Influence of floor space allowance and access to feed trough on the production of calves and young bulls and on carcass and meat quality of young bulls. *Acta Agric. Scand., Section A Anim Sci* 47:48-56.

Babcock A.H., White B.J., Dritz S.S., Thomson D.U., Renter D.G. (2009) Feedlot health and performance effects associated with the timing of respiratory disease treatment. *J Anim Sci* 87:314–327.

Béranger C. (1982) In: The welfare of cattle kept for beef production. European Commission, Scientific Committee on Animal Health and Animal Welfare, 25 April 2001.

Bouissou M.F., Signoret J.P. (1971) Cattle behaviour under modern management techniques. *Farm Building Assoc* 15 : 25-27.

Buhman M.J., Perino L.J., Galyean M.L., Wittum T.E., Montgomery T.H., Swingle R.S. (2000) Association between changes in eating and drinking behaviors and respiratory tract disease in newly arrived calves at a feedlot. *Am J Vet Res* 61:1163–1168.

Calsamiglia S., Castillejos L., Busquet M. (2006) Alternatives to antimicrobial growth promoters in cattle. Recent Advances in Animal Nutrition. P.C. Garnsworthy, and J. Wiseman, ed. Nottingham University Press, Nottingham, UK.Pages 129–167.

Church, T. L., Radostits, O. M. (1981) A retrospective survey of diseases in feedlot cattle in Alberta. *Can. Vet. J.* 22:27-30.

Edwards, A. (1984) Preventing Toe Abscesses. In: Feedlot Management April, pp 39-42.

Fisher A.D., Crowe M.A., Prendiville D.J., Enright W.J. (1997) Indoor space allowance: effects on growth, behaviour, adrenal and immune responses of finishing beef heifers. *Animal Science* 64 : 53-62.

Fucci D., Compiani R., Baldi G., Sgoifo Rossi C.A. (2012) Incidence of respiratory diseases and growth performance of high risk BRD newly received beef cattle treated at arrival. *Lar Anim Rev* 18(4)171-175.

Galyean M.L., Perino L.J., Duff G.C. (1999) Interaction of cattle health/immunity and nutrition. *Journal of Animal Science* 77(5):1120-1134.

Garcia M.D., Thallman R.M., Wheeler T.L., Shackelford S.D., Casas E. (2010) Effect of bovine respiratory disease and overall pathogenic disease incidence on carcass traits. *J. Anim Sci.* vol. 88:491–496.

Gardner B.A., Dolezal H.G., Bryant L.K., Owens F.N., Smith R.A. (1999) Health of finishing steers: Effects on performance, carcass traits, and meat tenderness. *J. Anim Sci.* vol. 77:3168–3175.

Gifford C.A., Holland B.P., Mills R.L., Maxwell C.L., Farney J.K., Terrill S.J., Step D.L., Richards C.J., Burciaga Roles L.O., Krehbiel C.R. (2012) Growth and development symposium: Impacts of inflammation on cattle growth and carcass merit. *J. Anim. Sci.* vol. 90:1438-1451.

Griffin, D., Perino, L. J., Hudson, D. (1993) Feedlot Lameness. In: University of Nebraska Lincoln Extension: University of Nebraska-Lincoln, 6.

Hanekamp W.J., Smits A.C., Wierenga H. (1990) Huisversting vleesstieren vanaf 6 maanden. Proefstation voor de Rundveehouderij Schpenhouderij en Paardenhouderij, *Lelystad*, Publication 66 pp.20.

Holland B.P., Burciaga-Robles L.O., VanOverbeke D.L., Shook J.N., Step D.L., Richards C.J., Krehbiel C.R. (2010) Effect of bovine respiratory disease during preconditioning on subsequent feedlot performance, carcass characteristics, and beef attributes. *J Anim Sci* 88:2486–2499.

Jim G.K., Booker C.W., Ribble C.S., Guichon P.T., Thorlakson B.E. (1993) A field investigation of the economic impact of respiratory disease in feedlot cattle. *Can Vet J* 34:668–1993.

Kimball S. R., Jefferson L. S. (2006) Signaling pathways and molecular mechanisms through which branched-chain amino acids mediate translational control of protein synthesis. *J. Nutr.* vol. 136:227S–231S.

Koberg J., Hofmann W., Irps H., Daenicke R. (1989) Rindergesundheit bei Betonspaltenbodenhaltung. *Prakt Tierazt* 70:12-17.

Konggaard S.P. (1983) Feeding condition in relation to welfare for dairy cows in loose housing systems. In Baxter, S.H., Baxter, M.R., and MacCornack, J.A.C. (eds). Farm animal housing and welfare. Martinus Nijhoff, The Netherlands, pp. 272-278.

Konggaard S.P., Larsson J.G., Madsen E.B., Nielsen K. (1984) Halatråd hos ungtyre. I. En epidemiologisk undersøgelse. Meddelelse 558. Statens Husdrybrugsforsøg. Frederiksberg, Denmark, 4 pp.

Ladewig J. (1987) Physiological results of welfare research in fattening bulls. In Schhlitin, M.C. and Smidt, D. (editors). Welfare aspects of housing systems for veal calves and fattening bulls. CEC Report, Luxembourg 123-129.

Larson R.L. (2005) Effect of cattle disease on carcass traits. *J. Anim. Sci.* vol. 83:E37–43.

Lofgreen G.P. (1983) Nutrition and management of stressed beef calves. *The Veterinary clinics of North America Large animal practice* 5(1):87-101.

Lutz P.V., Bogner H., Süss M., Perschke W., Fusseder J. (1982) Etologische Untersuchungen zum Tier/Fressplatsverhältnis bei Jungmastbullen in Laufstallungen. *Bayer Landwirtsch Wochenbl* 59:696-717.

Madsen E.B. (1987) Health aspects of welfare research in fattening bulls. In Schhlitin, M.C. and Smidt, D. (editors). Welfare aspects of housing systems for veal calves and fattening bulls. CEC Report, Luxembourg 131-138.

Madsen E.B., Thysen I., Ingvartsen K.L., Østergaard V. (1987) Health and production of young bulls at different stocking rates on slatted floors. Nat Inst Anim Sci Forum, Denmark, Report 628, 209-218.

Mossberg I., Lindell L., Johnsson S., Törnquist M., Engstrand U. (1992) Two housing systems for intensively reared bulls slaughtered in two weight ranges. *Acta Agric Scand Sect A Animal Sci* 42:166-176.

Mourkioti F., Kratsios P., Luedde T., Song Y.H., Delafontaine P., Adami R., Parente V., Bottinelli R., Pasparakis M., Rosenthal N. (2006) Targeted ablation of IKK2 improves skeletal muscle strength, maintains mass, and promotes regeneration. *J. Clin. Invest.* vol. 116:2945–2954.

Murphy P.A., Hannan J., Moneghan M. (1987) A survey of lameness in beef cattle housed on slatts and on straw. In Wierenga, H.K. and Peterse, D.J. (eds)., Cattle housing systems, lameness and behaviour. Martinus Nijhoff, Dordrecht, The Netherlands, pp. 73-86

Nickell J.S., White B.J. (2010) Metaphylactic antimicrobial therapy for bovine respiratory disease in stocker and feedlot cattle. *Vet. Clin. N. Am. Food An. Pract.* vol. 26(2):285–301.

Pahl H. (1997) The effect of different stocking densities on performance and profitability in fattening bulls. 1st communication: the effect on performance. *Zuchtungskunde* 69:181-195.

Panciera R.J., Confer A.W. (2010) Pathogenesis and pathology of bovine pneumonia. *Vet Clin North Am Food Anim Pract* 26(2):191–214.

Reeds P.J., Fjeld C.R., Jahoor F. (1994) Do the differences between the amino acid compositions of acute-phase and muscle proteins have a bearing on nitrogen loss in traumatic states? *J. Nutr.* vol. 124:906–910.

Roeber D.L., Speer N.C., Gentry J.G., Tatum J.D., Smith C.D., Whittier J.C., Jones G.F., Belk K.E., Smith G.C. (2001) Feeder cattle health management: Effects on morbidity rates, feedlot performance, carcass characteristics, and beef palatability. *Prof. Anim. Sci.* vol. 7:39–44.

Ruis-Heutinck L., Heeres-van der Tol J., Smits M., Smits D. (1999) Meer oppervlak geeft betere groei bijvleesstieren. *Prakijkonderzoek Rundvee, Shapen en Paarden*, 12:27-29.

Schaefer A.L., Cook N.J., Bench C., Chabot J.B., Colyn J., Liu T., Okine E.K., Stewart M., Webster J.R. (2012) The non-invasive and automated detection of bovine respiratory disease onset in receiver calves using infrared thermography. *Res Vet Sci.* 93: 928-935.

Schaefer A.L., Cook N.J., Church J.S., Basarab J., Perry B., Miller C., Tong A.K. (2007) The use of infrared thermography as an early indicator of bovine respiratory disease complex in calves. *Res Vet Sci.* 83: 376-384.

Schneider M.J., Tait R.G., Busby W.D., Reecy J.M. (2009) An evaluation of bovine respiratory disease complex in feedlot cattle: Impact on performance and carcass traits using treatment records and lung lesion scores. *J. Anim. Sci.* vol. 87:1821–1827.

Schneider MJ, Tait RG Jr, Busby WD, Reecy JM. (2009) An evaluation of bovine respiratory disease complex in feedlot cattle: Impact on performance and carcass traits using treatment records and lung lesion scores. *J Anim Sci* 87:1821-1827.

Sgoifo Rossi C.A., Compiani R., Baldi G. (2013) Inefficienze, che fare. *Informatore Zootecnico* 21:40-47.

Smits A.C. (1993) Vollspaltenboden mit Gummimattenin Vergleichstest. *DLZ* 32:86-98.

Sowell B.F., Branine M.E., Bowman J.P.G., Hubbert M.E., Sherwood H.E., Quimby W. (1999) Feeding and watering behavior of healthy and morbid steers in a commercial feedlot. *J Anim Sci* 77:1105–1112.

Tamminga S. (1992) Nutrition management of dairy cows as a contribution to pollution control. *J. Dairy Sci.* 75:345–357.

Tamminga S. (1996) A review on environmental impacts of nutritional strategies in ruminants. *J. Anim. Sci.* 74:3112–3124

The Orange Book (2004) Management of Risk - Principles and Concepts. Ed. HM Treasury.

Timsit E., Assié S., Quiniou R., Seegers H., Bareille N. (2011a) Early detection of bovine respiratory disease in young bulls using reticulo-rumen temperature boluses. *Vet J.* 190: 136-142.

Timsit E., Bareille N., Seegers H., Lehebel A., Assié S. (2011b) Fever episodes without visually apparent clinical signs in newly-received beef bulls at fattening operation: occurrence, duration and impact on performance. *J Anim Sci.* 89:4272-4280.

Van Nevel C. J., Demeyer D.I. (1988) Manipulation of rumen fermentation. In: The Rumen Microbial Ecosystem. P. N. Hobson, ed. Elsevier Applied Science, New York, NY. Pages 387–443.

Wee E., Wierenga H.K., Smits A.C., Smits M.C.J. (1989) Claw and leg disorders in cattle in relation to the design and constructions of floors. *Report Instituut voor Veeteeltkundig Onderzoek " Schoonord"*, B-345, pp 28.

Whay, H. R. (2009) A decade of pain: a look back over ten years of discovery about pain associated with lameness in cattle. In: Proceedings of Cattle Lameness Conference, School of Veterinary Medicine and Science University of Nottingham, Leicestershire, 19-22.

CHAPTER 2

Objectives

2. Objectives

Based on the assumption that improving animal health can be promoted growth performance reducing production costs and then driving beef sector to more profitability, has been performed four works discussed in this PhD dissertation.
The first two works presented in chapters 3 and 4 are the starting point of a risk management project about the two main typical diseases of beef cattle rearing. In fact, only knowing better and deeply all the possible risk factors and situations that can lead to a more susceptibility to a specific disease, can be planned correct preventive strategies.
The first work regards the presentation of a system for BRD risk assessment, main health problem in beef cattle rearing system worldwide. Because of the many stresses typical of the rearing system and the inevitable exposure to pathogens, incidences of BRD may be limited, but not avoided entirely. Based on these considerations, a system has been developed to assess the risk of BRD for each newly received group of beef cattle. The system takes into account all risk factors, which are divided into four categories. The objective is to identify the macro-area of rearing that would most benefit from closer consideration or modification. The first category includes risk factors associated with the inherent characteristics of each group of animals received; the following categories deal with environmental factors and specific factors linked to management practices, to the structures and to the nutritional management.
The second work is about lameness, another very important health problem in beef cattle system. The aim of this work was to review the existing literature on lameness causes and risk factors of beef cattle reared in the intensive system. Unfortunately, the literature about this topic is very little so, for a better analysis of lameness risk factors, were included in the dissertation the results of surveys performed in Italian intensive beef cattle rearing.
After knowing the risk and have understood which are some possible ways to avoid it mainly thanks to good operating procedure and farm structures, another key point to prevent disease is to promote cattle immunity and to promote a better recover after stressful events. For this reason, has been performed two trial focused on the evaluation of the effectiveness of two feeding strategies administered during the adaptation phase.

The first trial discussed in chapter 5 is about the effects evaluation of selenium dietary supplementation from organic and inorganic sources to newly received beef cattle imported from France to an Italian fattening facility. Selenium ability to improve immune response is already known for decades and several studies showed that the bioavailability and biopotency of selenium from organic sources is higher than that from inorganic ones. For this reason were evaluated the effects of this strategy to promote immune response, antioxidant abilities and growth performance, reducing morbidity and after transport stress.
In the last, another trial was performed to evaluate the effects of the administration of a mixture of specific essential oil to newly received beef cattle. The effects of dietary administration of several essential oils to ruminants have been widely investigated *in vitro*, but very few instead in field situations. Furthermore, since essential oils are potentially able to stimulate rumen fermentation by affecting the quantity and quality of volatile fatty acids produced and the nitrogen ruminal metabolism, this study aimed to evaluated the effects of the administration of cinnamaldehyde, eugenol, and capsicum essential oils on the growth performance and health status of beef cattle during the adaptation phase.

CHAPTER 3

Determination and assessment of BRD risk factors in newly received beef cattle

Published in:
Large Animal Review, Vol. 19, 65-72, 2013.

3. Determination and assessment of BRD risk factors in newly received beef cattle

AUTHORS: C.A. Sgoifo Rossi*, R. Compiani*, G. Baldi*, M. Bonfanti**
**Department of Health, Animal Science, and Food Safety (VESPA), University of Milan*
***Veterinarian, Ph.D., MSD Animal Health*

3.1 Abstract

Bovine Respiratory Disease (BRD) is the main health problem in intensive beef cattle rearing. BRD is a multifactorial syndrome, and its etiopathogenesis is influenced by several predisposing and triggering factors. Management of the numerous risk factors is essential to maintaining appropriate preventative and therapeutic practices in the rearing of feedlot cattle. Because of the many stresses and the inevitable exposure to pathogens, incidences of BRD may be limited, but not avoided entirely. We propose a system for evaluating the potential risk of BRD for each new delivery of feedlot cattle, using a point attribution system that scores the principal risk factors of the production system, which is in turn able to judge the susceptibility of the animals to respiratory disease. The comprehensive risk assessment begins with an assessment of subject inherent risk in relation to weight, sex, race, transport length, transportation shrink, and the management practices of the breeding farm, which can be exacerbated or reduced by the management practices and structures present at the fattening facility. The analysis of risk allows for the focused management of each newly received lot of cattle in relation to its probable incidence and severity of BRD, providing the basic conditions for effective prevention and management of respiratory disease in the rearing of fattening cattle. Analysis of the data generated by the risk assessment system allows the quantification of the impact of each risk factor on the farm balance sheet, highlighting the cost-effectiveness of changes to management practices and investments in structural equipment.

3.2 Introduction

Bovine Respiratory Disease (BRD) is the main health problem in intensive beef cattle rearing and is considered a multifactorial syndrome. While its etiopathogenesis has been widely studied and is for the most part well known,

common rearing practices often do not take into account that the correct management of any risk factor can influence the incidence and severity of BRD. As a direct consequence, the worldwide incidence of BRD in the rearing of beef cattle is extremely variable, but nevertheless very high (Panciera and Confer, 2010).

A multifactorial syndrome can be conceptualized as an interaction between an organism and the environment in the presence of pathogens of variable specificity. By regulating the interaction of these three factors, it is possible to prevent the onset of the syndrome or at least decrease the severity (Gonzales et al., 2011).

Unfortunately, the particular characteristics of intensive beef cattle rearing lead to very difficult managing of these risk factors complex in practice. Young cattle experience an inevitable series of stressful events between transport, adaptation to new environments, new social interactions, contact with humans, new feeding regimes, and exposure to variable and numerous pathogens at the collection centers (Panciera and Confer, 2010). The medical research, over the course of the last ten years, has described ways to control BRD through specific vaccines and new antibiotics, but these methods are heavily influenced by both the immunological state of the animal and its environment (Ackermann et al., 2010).

Controlling the isolated microorganisms involved in BRD is important, but understand and manage risk factors remains the best method to limit the negative impacts on the herd and, consequently, on the profitability of cattle production. Both management practices and the rearing environment can be risk factors for BRD, as can be seen clearly in Table 1, which reports the incidence of health problems in three farms using the same type and timescale of preventative health measures, performed under different management practices.

As the management conditions worsen, the incidence of BRD increases (from 6.5 to 28.4%) in addition to problems of the locomotor apparatus. The pen density, cleanliness of the environment, the type of drinking trough, the training of personnel on appropriate animal contact, and nutritional management all emerge as important risk factors. The variability between different stocks of beef animals, with respect to, for example, sex, age, breed, and transport duration and conditions, strongly influences the severity of the disease (Waltner-Toews et al., 1986; Coffey et al., 2001; Galmozzi et al, 2009). Therefore, to limit the effect of these variables on the evaluation between different management practices and BRD, a monitoring study of health problems was conducted in a large farm

between 2007 and 2011. Groups of animals were controlled for the season of arrival at the fattening unit, sex, breed, weight and transport conditions, and placed under different management practices during the course of the five-year observation period.

Table 1. Main health problems and management in 3 different farms (personal data).

Farm	**1**	**2**	**3**
Management	**Very good***	**Fairly good****	**Poor*****
Number of animals	9,844	2,082	3,403
Bovine Respiratory Disease (BRD), %	6.50	14.20	28.40
Locomotor Apparatus Diseases (LAD), %	1.85	3.53	6.03
Foot diseases, %	0.24	0.88	3.46
Arthropathies, %	1.61	2.65	2.57

*Very good: density >4.5 m^2/head, bedding straw added daily, water troughs with float valve, very good interaction between animals and humans, more than 5 dietary steps
**Fairly good: density 3.5-4.5 m^2/head, bedding straw added every 2 days, water troughs with float valve, very good interaction between animals and humans, 3 to 5 dietary steps
***Poor: density <3.5 m^2/head, bedding straw added every 5 days, nose-activated water troughs, poor interaction between animals and humans, 2 to 3 dietary steps

As can be seen in Table 2, in 2010 the incidence of BRD was drastically reduced like "problem" cattle and cattle moved to the infirmary compared to the incidence in the three years prior. Among the notable structural changes and changes in management undertaken in 2010 was the construction of a technologically advanced alley, within which all preventative treatments were performed. All newly arrived cattle were weighed and clipped in the new alley, allowing better homogeneity of the heads inside the boxes. Furthermore, the number of heads per pen was reduced by 20%, increasing the space available per head from 3 m^2 to more than 4 m^2. Finally, the turnover of the animals was optimized to guarantee increasing holding time in the quarantine zone.
While the rearing environment plays a fundamental role in the reduction or amplification of BRD risk, this remains fundamentally linked to the animal or group of animals received. The newly received cattle, in addition to being particularly susceptible to an array of health problems, are still young with incompletely developed immune systems, depressed by the stressful situations described above, and arrive at the fattening farms in almost every case without a complete medical history, which creates further complexity in the evaluation of BRD risk and the implementation of related strategies for disease control.

Table 2. Monitoring the incidence of BRD in a single farm (personal data).

Year	Heads, n.	BRD, %	Mortality, %	"Problem" cattle, %	Moved to hospital pen, %
2007	17122	40.7	0.68	0.70	12.31
2008	14899	34.4	0.80	0.77	16.83
2009*	14044	30.1	0.55	0.38	15.49
2010	12830	24.9	0.53	0.26	2.70
2011	12937	25.8	0.51	0.29	3.01

* Implementation of new structures and modification of management practices.

3.3 Risk assessment

Based on these considerations, a system has been developed to assess the risk of BRD for each newly received group of beef cattle. The system takes into account all risk factors, which are divided into four categories. The objective is to identify the macro-area of rearing that would most benefit from closer consideration or modification. The first category includes risk factors associated with the stock of animals received; the following categories deal with environmental factors and specific factors tied to the management practices, to the structures and to the nutritional management.

The system is based on attributing points for every risk factor, positive points in the case of elevated risk of BRD, zero in the case of unaltered risk, and negative in the case where conditions allow a reduction of comprehensive risk. The point value of each factor has been calculated based on data from previous publications and analysis of a database of over 180,000 heads, collected over the last 15 years from professionals and veterinarians working in the beef cattle industry in Italy.

3.3.1 Subject inherent risk

The characteristics of the newly arrived animal considered to impact the risk are the sex, weight, genetic type, and age. For example, characteristics considered to carry a greater risk are animals of the female sex, very young and reduced weight animals (Hartwing et al., 1999; Galmozzi et al., 2009) of the Limousine and Blonde d'Aquitaine breed. On the other hand, crossbred 16-month-old males weighing more than 480 kg live weight are considered to be low risk for contracting BRD. These characteristics, together with transport duration, are

closely connected with weight loss, which, if elevated, can negatively influence the risk tied to the animal (Cernicchiaro et al., 2012). The arrival season is another factor that influences BRD risk, where the end of autumn and winter in particular are periods in which the local defenses in the airways of young cattle, because of cold temperatures, increased humidity levels, and the difficulty of transport, are less able to react to the pathogens responsible for BRD (Ackermann et al., 2010).

Table 3. Form for assessing risk tied to the animal.

Risk score	**6**	**7**	**10**	**15**	**18**
Weight at arrivale, kg	> 480	400-480	330-400	250-330	<250
Weight loss, %	<4	4-6	6-8	8-10	>10
Sex	Steer	Male	Female	-	
Season	Summer	Early autumn	Spring	-	Late autumn, winter
Breed	Ch x Aub/Sal crossbreed	Aubrac, Saler	Ch x Lim crossbrees, Charolaise	Limousine	Blonde D'aquitaine
Age, months	>16	13-16	10-13	7-10	<7
Transport lenght, h	<8	8-12	12-24	>24	>48
Management in the origin farm	Conditioned animals (antiviral, antibacterial and antiparasitic prophylaxis)	Conditioned animals (antiviral prophylaxis for respiratory disease)	Conditioned animals (enterotoxemia prophylaxis)	Not conditioned or vaccinated	No information
	Weaned for over 60 d	Weaned from 30-60 g	Weaned for less than 30 d	Not weaned	No Information
	Ad libitum feed in addition to milk and grazing	Rationed feed in addition to milk and grazing	-	No feed other than milk and grazing	No Information
	Cleared for BVD and IBR	Cleared for BVD or IBR	-	Not cleared for BVD and IBR	No information

Beyond the characteristics of the animals themselves, the management practices of the original breeding farm are essential to assessing the risk tied to the animal (Thomson, 2006). One of the most important critical point in Italian beef system is the lack of information or imprecise information on the medical history prior to the arrival at the fattening units. Because of this and in order to urge the fattening facilities to develop positive relationships with the suppliers, a particularly high point score has been given for this absence of information, which is a situation deemed more risky than even a known negative health status. An animal that has not undergone any vaccine protocol, that has been weaned for a short time, that has not undergone feed conditioning, and that comes from a structure not cleared for BHV_1 or BVDV carries serious risk factors, but this information, if known, can allow the veterinarian and the farm personnel to opt for specific relevant interventions (Table 3).

3.3.2 Assessment of operating procedures

Like the risk associated with the health and nutritional management of animals in the breeding farm, detailed information on the intermediate handling can be important in later management choices. The method and duration of transport, the holding time and management in collection centers, or the restricted feeding and watering times are important factors that can assist in the evaluation of BRD risk (Ackermann et al., 2010).

Very large farms, with an annual turnover of more than 10,000 heads are considered high risk, regardless of management practices. Even though these structures are quite always characterized by specific and efficient management procedures, and by a satisfactory ratio between the number of animals and the functional structures, the significantly higher microbes circulation and the greater risk of error or of time delays in the identification of problems cannot be discounted. This risk can be attenuated at the time of unloading with the evaluation of weight loss and during grouping activity, as a careful observation of the animal's characteristics can reveal sick subjects even in this early phase. Groups should be formed with animals as homogenous as possible, with respect to weight and breed, and it is good practice to avoid or limit remixing. BRD risk is increased, and the point score is penalized, in pens containing an excessive number of animals (Losinger and Heinrichs, 1996). Groups of less than 10 animals, which are furthermore much easier to inspect, allow a better separation of highly contagious pathogens (Table 4).

Particular attention should be paid to the conditioning procedure, that is, the vaccinations, antiparasitic treatment, and any preventative antibiotic treatment (metaphylaxis). With regard to vaccination protocols, a penalty has been applied to the administration of standard protocol treatments that are not based on an evaluation of the specific conditions of the animalas. The best practices for reducing BRD are considered to be the selection of a vaccine protocol based on the risk tied to the individual cattle group and to the environmental conditions where the cattle will be reared. Lower risk situations, based on the animals and the season, call for a polyvalent antiviral and focused antibacterial protocol with associated booster shot. The practice of vaccinating animals in poor health condition upon arrival is not recommended, as it is considered a limiting factor to the risk to undertake this procedure in a manner and timescale dependent on the health conditions of the animals. In this sense, the most at-risk cases would benefit from a course of intra-nasal multivalent vaccinations, in order to quickly encourage the development of a local immune response in the respiratory tract (Plummer et al., 2004). With regard to the problem of parasites, it is good practice to establish a focused protocol for endo and ecto parasites based on, for example, the provenance of the animals. In addition to pharmacological treatment, it is a good idea to clip the back at arrival and performer periodic ectoparasitic treatments.

Particular attention must be paid to the use of antibiotics; in fact, the correct use of a metaphylactic protocol can greatly limit the impact of BRD (Galmozzi et al., 2009; Nickell and White, 2010; Fucci et al., 2012).

Risky practices include both the mass treatment with antibiotics upon arrival and in the absence of obvious disease, and the use of a standard protocol, even for the individual treatment of animals with clinical symptoms. A substantial reduction in risk can be obtained by using a protocol that combines individual treatment of each diseased animal followed by a timely and specific metaphylaxis protocol with long-acting pharmaceuticals as the morbidity of the group reaches 10% (Nickell and White, 2010). The correct administration of metaphylaxis requires that the diseased animals are detected early, and it is therefore good practice to check the animals often and regularly during the adaptation phase, monitoring the rectal temperature for several days after their arrival.

Table 4. Form for self-assessment of the risks tied to operating procedures in beef cattle.

Operating procedures		Risk
Pre-arrival information (select more than one, if applicable)	I have detailed information on the following points	-2
	I do not have information about the movement (method and duration of transport, markets, etc.) of the animals before arrival at the collection center	2
	I do not have information on the holding time and the management of the collection centers	2
	I do not know the transport conditions and the feed and watering restriction times	2
Number of cattle reared per year	< 500	1
	500-1,000	2
	1,000-2,500	3
	2,500-5,000	5
	5,000-10,000	8
	> 10,000	10
Unloading	I carefully assess weight loss, travel conditions (duration, climate, stops, etc.) and perform a careful and thorough individual check of the animals at unloading	-2
	I perform a careful individual check at unloading	0
	I perform an aggregate check at unloading	2
Vaccinations	Polyvalent antiviral and focused antibacterial protocol based on the animals and the season, with associated booster shot	-6
	Polyvalent antiviral vaccine with associated booster shot with standard protocol	-2
	Polyvalent antiviral vaccine covering only some strains with associated booster shot and with a focused protocol	0
	Antiviral vaccine covering only some strains with associated booster shot and with a standard protocol	3
	Antiviral vaccine covering only some strains without associated booster shot and with a standard protocol	10
Antiparasitic treatments	Focused protocol for endo- and ecto- parasites with clipping and periodic ectoparasitic treatment	-3
	Protocol for endo- and ecto- parasites upon arrival without clipping and periodic ectoparasitic treatment	0
	Protocol for endo- and ecto- parasites upon arrival without clipping and ectoparasitic treatment when necessary	1
	Endo- and ecto- parasitic treatment when necessary	3
Performance of preventative treatments	With methods and timetables dependent on the health conditions of the animals	-3
	Independent of the health conditions of the animals	3

Table 4 (follows). Form for self-assessment of the risks tied to operating procedures in beef cattle.

Operating procedures		Risk
Animal checks	Individual temperature checks in the days after arrival	-3
	Inspections inside the box in the morning and outside the box in the evening	0
	Inspections inside the box in the morning	2
	Inspections outside the box	3
Antibiotic treatments	I treat each individual sick animal and adopt timely (better if based on the body temperature of the animal) and specific metaphylaxis protocols with long-acting pharmaceuticals when morbidity reaches 10%	-6
	I treat each individual sick animal and adopt timely and specific metaphylaxis protocols with short/medium-acting pharmaceuticals when morbidity reaches 10%	0
	I perform a preventive mass antibiotic treatment upon arrival based on a standard protocol	3
	I treat the obviously sick animal without adopting metaphylaxis protocol	10
Antibiotic selection	I perform periodic checks to identify circulating pathogens and their susceptibility to treatment	-1
	I perform periodic checks to identify circulating pathogens and their susceptibility to treatment only in the case of serious epidemics	0
	I use treatment drugs without first verifying circulating pathogens and their susceptibility to the active ingredients	3
Group formation	High homogeneity with regard to weight and breed	-1
	Low homogeneity with regard to weight and breed	2
	Random assignment with mixing during the production cycle	3
Group numbers	Less than 10 animals per group	0
	10-20 animals per group	2
	20-30 animals per group	4
	More than 30 animals per group	10
Quarantine management (completely full to completely empty)	More than 15 days	-1
	7-14 days	0
	Not more than 7 days	2
	Not performed	3
Cleaning and disinfection of the adaptation pens after each delivery of animals	Cleaning and disinfection	-1
	Cleaning	0
	Changing of the bedding and/or disinfection of soiled surfaces	2
	No procedure	3

Finally, to minimize the exposure of newly arrived cattle to environmental pathogens, it is good practice to perform a thorough cleaning of the waste management system in the adaptation zone and completely remove the bedding of the previous group, thoroughly washing and disinfecting the structure.

3.3.3 Assessment of farm structures

Table 5 gives the point scores related to the quarantine and adaptation zone structures.

It can be beneficial to have an easily accessible feed bunk or rack to be used by all animals simultaneously, watering troughs, ergonomic and functional access points and gates, which should be used throughout the rest of the farm as well.

Table 5. Form for self-evaluation of the risk connected to the farm structures.

Structure		**Risk**
Specific and functional structure for moving and healthcare treatment of animals (alley)	Present, with a self-catching cattle chute	-2
	Present	-1
	Absent	2
Isolated pens for adaptation/quarantine phase	Present	-3
	Absent, or not used	3
Holding time in the adaptation/quarantine zone	> 30 days	-3
	20-30 days	1
	< 20 days	5
	0	10
Cooling systems	Present	0
	Absent	1
Water troughs in the pens for newly arrived cattle	Note activated	3
	Float valve	0
Floor surface in the pens for newly arrived cattle	Straw bedding	0
	Slatted	6
Space in the feed bunk	< the number of heads	3
	= the number of heads	1
	> the number of heads	-1
Ergonomic structures (racks, feed bunk, water troughs, entries, gates, etc.) for the animals	Present	0
	Absent	2
Isolated hospital pen	Present	-1
	Absent	3

We mentioned previously how important it is to correctly administer the specific vaccination plans and antibiotic treatments in a timely manner, and a structure

for this specific purpose is indispensable. A well-adapted alley provides a space to apply these protocols correctly and to work in a safe and efficient manner. A self-catching cattle chute at the end of the corral would be particularly advisable in this context.
These structures benefit from having float valve water troughs, since cattle arriving from the pasture are less likely to be habituated to nose activated water troughs, which could potentially aggravate their already dehydrated state developed during transport (Pinheiro et al., 2004). For the same reason, a slatted floor in the adaptation pen is considered a risk factor with respect to a well-kept bedding floor (Assié et al., 2009).
A final factor that can reduce the risk of BRD is the use of an isolated hospital pen for sick animals, which minimizes microbes circulation.

3.3.4 Assessment of nutritional management

Poor nutritional management can compromise the health of animals in the post-adaptation phases, the phases in which an excess or inadequate level of nutrition can easily lead to typical problems including acidosis, bloat, and locomotor apparatus diseases.
With respect to respiratory problems, the importance of nutritional management represents an indirect risk factor, and it would be difficult to scientifically support the claim that an unbalanced diet leads to a predisposition to BRD.
On the other hand, correct nutritional management, starting from the arrival at the fattening unit, can undoubtedly accelerate the re-equilibration of the physiological conditions of the rumen and indirectly aid immune system function in terms of local and systematic defenses, as well as aid the reactivity to vaccinations (Sweiger and Nicholas, 2010).
As described in detail in Table 6, the administration of a specific diet during the adaptation phase is considered to be a practice that can reduce the risk of BRD.
A diet with adequate energy and protein content that contains a specific vitamin and mineral supplementation will support the equilibration of the basic functions following the metabolic imbalance induced by the stress of transport and adaptation (Sweiger and Nicholas, 2010). A TMR diet should be administered ad libitum, together with unlimited supply of good and long cut hay, for at least one week, and thereafter must not be changed abruptly but progressively changed to the fattening diet to allow the ruminal flora and fauna to adapt and guarantee a greater level of nutrition.

Table 6. Form for self-evaluation of the risk connected to nutritional management.

Parameter		Risk
Feeding system	TMR	0
	Traditional	1
Method of administration	Ad libitum	-1
	Rationed	2
Diet in the adaptation phase	Specified for arrival with UFC/kg dm < 0.90 and CP/kg dm < 13% and gradual adaptation to the fattening diet	-2
	Specified for arrival with UFC/kg dm < 0.90 and CP/kg dm < 13% without gradual adaptation to the fattening diet	0
	Ad libitum administration of a percentage of the fattening diet mixed with forages of an adequate length	3
	Part of the fattening diet	5
Mineral and vitamin supplementation in adaptation phase	Specific mineral and vitamin mix phase	-1
	Additional supplementation of a standard min and vit mix	0
	No additional min and vit supplementation	5
Availability of long forage in the days after arrival in addition to the ration	Hay always available during the course of the first 7 days	-1
	Rationed hay available in the course of the first 7 days	1
	Hay only on the first/second day after arrival	2
Chemical characteristics check of TMR	At least one analysis per year	0
	No analysis	1
Chemical characteristics check of silages	At least two analyses per year	-1
	Once per year	0
	No analysis	2
Health characteristics check of raw materials	Periodic analysis for products at risk (micotoxins)	-1
	Occasional analysis for products at risk (micotoxins)	0
	No analysis	2
Health characteristics check of silages	Periodic monitoring of micotoxins	-1
	Occasional monitoring of micotoxins	0
	No analysis	2
Physical characteristics check of TMR	Frequent and instrumental checks	-1
	Frequent visual checks	0
	Occasional visual checks	1
	No checks	2
Check for accuracy and precision of diet preparation	System present to register the quantity loaded and the mixing time	-1
	Impossible to verify	2

The positive consequences of a well-considered food-conditioning protocol could be easily compromised by the use of feed not conforming to nutritional standards or containing undesirable substances like mycotoxins. These, in particular, interfere negatively with the ruminal fermentation itself during a phase in which it is necessary to promote it (Sgoifo Rossi and Compiani, 2011). The absence of frequent checks of the chemical and microbiological composition of the raw materials and in particular the silages constitute a risk factor. Finally, beyond the administration of a specific diet with safe raw materials, careful attention must be paid to the preparation of the rations. The objective is to obtain a TMR with an appropriate fiber content, which can't be easily separated from the other components. Checking the food supply and preparing the rations represent operations that can limit the risks of any other health problem and promote appropriate weight gain in the animals.

3.3.5 Comprehensive risk

The comprehensive risk arises from the sum of the subject inherent risk (from 48 to 136), the rearing environment risk, which falls under the operating procedures (from -28 to +69), the structures (from -10 to +33) and the nutritional management (from -10 to +26). Groups with a comprehensive risk of less than 60 are considered low risk, while a score between 60 and 110 is considered medium risk, a score between 110 and 200 high risk, and a score above 200 extremely high risk. The ideal situation is one in which a higher risk score tied to the animal is reduced by sum of the other points and the maintenance of good management practices.

3.4 Final considerations

The identification of the multiple risk factors and the quantification of their negative effects allow to the evaluation of suitable and well-considered health interventions with respect to the risk connected to the newly arrived animals. Often, correct health approaches, when used in an environment that is not completely adequate or along with a management approach unsuitable to the level of risk of the stock, can appear inefficient and call the professionalism of the veterinarian into question. The system developed here should not be considered an all-encompassing theorem that completely solves the problem of BRD in the rearing of beef cattle, but can instead be used as a dynamic

instrument available to the veterinarian trying to limit the negative impacts of the disease and as a referral technique for the farmer, who can precisely quantify the economic impact of every single risk factor, for use in planning to decrease the uncertainty when making investment decisions about necessary interventions and other realities of farming.

To achieve this objective it is indispensable to increase the quantity and quality of data available. This project will continue in an intense effort to archive and analyze the point scores of the diverse risk factors of numerous gropus of newly arrived animals, cross referencing the strategic health outcomes (morbidity and mortality), the relative costs where available, and the growth performance of the lots.

This method represents, in conclusion, the goal of evaluating the real capacity of various preventative and therapeutic strategies to modulate the negative interaction between subjects, the environment, and pathogenic microorganisms, limiting the negative effects of BRD on the health of beef cattle and on the quality and profitability of production.

3.5 References

Ackermann M.R., Derscheid R., Roth J.A. (2010) P Innate immunology of bovine respiratory disease. *Vet Clin N Am-Food An Prac*, 26(2):215–228.

Assié S., Bareille N., Beaudeau F., Seegers H. (2009) Management- and housing-related risk factors of respiratory disorders in non-weaned French Charolais calves. *Prev Vet Med*, 91:218-225.

Cernicchiaro N., Renter D.G., White B.J., Babcock A.H., Fox J.T. (2012) Associations between weather conditions during the first 45 days after feedlot arrival and daily respiratory disease risks in autumn-placed feeder cattle in the United States. *J Anim Sci*, 90(4):1328-1337.

Coffey K.P., Coblentzw K., Humphry J.B., Brazle F.K. (2001) Review: basic principles and economics of transportation shrink in beef cattle. *Prof Anim Sci*, 17:247-255.

Fucci D., Compiani R., Baldi G., Sgoifo Rossi C.A. (2012) Incidence of respiratory diseases and growth performance of high risk BRD newly received beef cattle treated at arrival. *Large Anim Rev*, 18(4):171-175.

Galmozzi G., Muraro M., Vandoni S., Bonfanti M., Faccini S., Rosignoli C., Sgoifo Rossi C.A. (2009). Treatment regimes of respiratory disease in newly received feedlot cattle. *Large Anim Rev*, 15(6):257-266

González-Martín J.V., Elvira L., Cerviño López M., Pérez Villalobos N., Calvo López-Guerrero E., Astiz S. (2011) Reducing antibiotic use: Selective metaphylaxis with florfenicol in commercial feedlots. *Livest Sci*, 141(2-3):173-181.

Hartwig N., Faber R., Busby D., BreDahl R. (1999) The costs and predictive factors of bovine respiratory disease in standardized steer tests. *Beef Research Report*, Iowa State University.

Losinger W.C., Heinrichs A.J. (1996) Management variables associated with high mortality rates attributable to respiratory tract problems in female calves prior to weaning. *J Am Vet Med Assoc*, 209:1756-1759.

Nickell J.S., White B.J. (2010) Metaphylactic antimicrobial therapy for bovine respiratory disease in stocker and feedlot cattle. *Vet Clin N Am-Food An Prac*, 26(2):285–301.

Panciera R.J., Confer A.W. (2010) Pathogenesis and pathology of bovine pneumonia. *Vet Clin N Am-Food An Prac*, 26(2):191–214.

Pinheiro Machado Filho L.C., Teixeira D.L., Weary D.M., von Keyserlingk M.A.G., Hotzel M.J. (2004) Designing better water troughs: dairy cows prefer and drink more from larger troughs. *App An Behav Science*, 89:185–193

Plummer P.J., Rohrbach B.W., Daugherty R.A., Thomas K.V., Wilkes R.P., Duggan F.E., Kennedy M.A. (2004) Effect of intranasal vaccination against bovine enteric coronavirus on the occurrence of respiratory tract disease in a commercial backgrounding feedlot. *J Am Vet Med Assoc*, 225(5):726-731.

Sgoifo Rossi C.A., Compiani R. (2011) Bovine mycotoxicosis. *Large Anim Rev*, 17(6):237-245.

Sweiger S.H., Nichols M.D. (2010) Control methods for bovine respiratory disease in stocker cattle. *Vet Clin N Am-Food An Prac*, 26(2):261-271.

Thomson D.U. (2006) Backgrounding beef cattle. *Vet Clin N Am-Food An Prac*, 22(2):373-398.

Waltner-Toews D., Martin S.W., Meek A.H. (1986) The effect of early calfhood health status on survivorship and age at first calving. *Can J Vet Res*, 50(3):314-317.

European Community (1997) Treaty of Amsterdam amending the treaty on European Union, the treaties establishing the European Communities and certain related acts. Amsterdam on 2 October 1997.

Broom D.M. (1986) Indicators of poor welfare. *Br. Vet. J.* 142-524.

Kjaernes U., Harvey M., Warde A. (2009) Trust in Food - A Comparative and Institutional Analysis. Ed Palgrave Macmillan.

CHAPTER 4

Dealing with lameness in Italian beef cattle rearing

Published in:
Italian Journal of Animal Science, in press, 2014.

4. Dealing with lameness in Italian beef cattle rearing

AUTHORS: R. Compiani*, C.A. Sgoifo Rossi*, G. Baldi*, A. Desrochers**
**Department of Health, Animal Science, and Food Safety (VESPA), University of Milan*
*** Département des Sciences Cliniques, Faculté de Médecine Vétérinaire, Université de Montréal*

4.1 Abstract

Lameness is one of the main health and economic issues concerning not only dairy but even beef cattle production system. Lameness is a clinical condition in case of locomotor apparatus diseases (LAD) and is characterized by multiple triggering (microbial, mechanical, nutritional, and genetic) and predisposing factors (subjective and environmental). The aim of this work was to review the lameness causes and risk factors of beef cattle reared in the intensive system and in particular in the Italian situation. The results of the surveys proposed, show that in Italian intensive beef cattle rearing, LAD is an important problem characterized by variable incidence and different risk factors. Heavy Charolaise bullocks are more predisposed to LAD. Floor is one of the main risk factor, but the right choice of which animal will be housed on slatted floor can strongly limit arthropathy incidence and a proper litter management can prevent foot diseases. Other livestock facilities and management can limit or promote LAD incidence and severity. Furthermore even feed quality control, a proper vitamins and minerals integration and the gradual transition from arrival to finishing diet, limit acidosis events and then laminitis. The right diagnosis and the knowledge of the main features related to LAD can help and speed up the decision-making process not only about the fate of a specific lame animal but also to identify the cause behind of a widespread problem in the herd. In this way, can be adopted specific preventing strategies in order to limit drugs administration, not essential in every case of lameness.

4.2 Introduction

Locomotor apparatus diseases (LAD) in cattle is gaining more attention recently because of welfare issue and economic loss (Cha et al., 2010; Bruijnis et al.,

2013). In dairy cattle, lameness was associated with decrease milk yield and fertility (Collin et al., 1989; Hernandez et al., 2001, 2002). Digital dermatitis and claw horn disruption are the most significant diseases affecting dairy cattle around the world (Amory et al., 2008; Zecconi et al, 2010; Sagliyan et al., 2010; Brizzi, 2010; Project TADHH, 2012;). In dairy, LAD are one of the main cause of early culling just after low fertility and mastitis (Enting et al., 1997). LAD are also frequent in beef cattle but there is scant literature on the subject in Europe. Prevalence of lameness in Norwegian beef cows was studied in 12 herds. Lameness was recorded in 1.1% of the animals with laminitis like lesions and infectious feet problems being the most common diseases (Fjendaas et al., 2007). In the US beef industry, economic loss from lameness is significant. Selling price of a lame cow is significantly decreased (Ahola et al., 2011). A national survey on bull beef quality in US concluded that a high percentage of carcasses had inadequate muscling, arthritic joints and bruises (Roeber et al., 2011). Other economic losses due to LAD are well quantified and include costs for therapies and laboratory analysis, reduction of weight gain, early culling and in the most severe cases, the death of those animals which do not respond to treatments (Miskimins, 2002).

Table 1. Total morbidity and BRD and LAD incidence in north America feedlot.

Reference	**Church and Radostits, 1981**	**Edwards, 1984**	**Griffin et al., 1993**
Place	Canada	Kansas, USA	Nebraska, USA
Number of animals	294,144	250,521	1,843,652
Total morbidity, %	12.87	9	13.1
BRD incidence, % (% of morbidity)	7.55 (58.66)	6.03 (67)	-
LAD incidence, % (% of morbidity)	2.73 (21.21)	1.98 (22)	2.1 (16)
foot disease among LAD cases, %	97	70	70

Based on the literature, it seems that the origin of lameness in beef cattle is more various than in dairy cattle (Persson et al., 2007; Heinola et al., 2006; Gagea et al., 2006a, 2006b; Hewicker-Trautwein et al., 2002; Barth and Waldner, 2002; Stokka et al., 2001; Davies and Munro, 1999; Weisbrode et al., 1982; Jensen et al., 1980,

1981; Reiland et al., 1978; Murphy et al., 1975) including: trauma, osteochondrosis, septic arthritis and epiphysitis. According to one study, lameness originates from the foot in nearly 90% of lameness in dairy and approximately 70% in beef cattle (Griffin et al., 1993; Miskimins, 2002).
Surveys conducted in north America (Table 1) show that LAD incidence is between 16 and 22% of total morbidity (Church and Radostits, 1981, Edwards, 1984; Griffin et al., 1993). Is also important to underline that LAD incidence in these studies was second only to bovine respiratory disease (BRD), which is the main problem in beef cattle rearing all over the world (Townsend et al., 1989; Griffin et al., 1993; Panciera and Confer, 2010).
The aim of this paper was to review the literature on lameness causes and risk factors of beef cattle reared in the intensive system related to the Italian system or situation. In addition we wanted to describe the main beef LAD in order to better understand the real incidence of this problem. Finally, we will review some of the main LAD risk factors.

4.2.1 Italian beef cattle production system

Italian beef cattle's rearing is mainly based on fattening young cattle imported mostly from France to dedicated facilities in Northern Italy. The most common breeds imported from France are: Charolaise, Limousine and crossbreed. Gender (female and intact male) and weight are variable with a weight of 220-500 kg upon arrival. The livestock is generally in indoor housing on slatted floor or straw litter. In relation to management issue, LAD in this scenario are mainly on nutritional base. That's because, in order to achieve appropriate weight, conformation and fatness to meet the Italian consumer requests and in the shortest time to reduce production costs, animals receive diets characterized by high nutritional level and high quantity of fermentable carbohydrates which can lead to acidosis and therefore to laminitis (Greenough, 2007). Otherwise, many other factors may predispose to LAD or complicate the clinical findings including sex, race, weight, season, housing type and quality of management.

4.3 Locomotor apparatus diseases

Hereinafter are reported some of the main LAD that can affect cattle. In Table 2 are summarized some features about lameness divided by body area of onset. For each disease are reported the possible severity of lameness, the position

adopted from the affected limb, the degree of pain at palpation and swelling. Furthermore are reported which specific physical exam or particular diagnostic test that the veterinary needs to formulate a correct diagnosis and then prognosis, treatment and future prevention strategies.
Table 2 reports even some problems with a very poor prognosis as specific fractures that can be confused with joint problems. The knowledge of these problems is important because a decision must be taken rapidly to save the meat and at the same time on a welfare standpoint.

4.3.1 Laminitis or claw-horn disruption

Claw-horn disruption is by definition any event, pathology that will influence claw-horn growth. Subclinical laminitis is often associated to horn growth abnormalities. The clinical manifestations are poor horn quality, sole hemorrhage, sole ulcers and white line disruption. Laminitis is one aspect of claw-horn disruption. Laminitis by definition is the inflammation of the lamella of the foot. The term laminitis was borrowed from the equine condition because of similar clinical signs. The events leading to the ultimate sinking of the pedal bone seems to be different in cattle (Lischer et al., 2002; Ossent and Lischer, 1998). In horses and cattle, the horn is attached to the corium (sensitive part of the claw) by lamellae which are very small leaflets providing nutritive supply to the non-sensitive horn. The corium is attached to the pedal bone. In horses, the inflammation of the lamellae will create a separation of the sensitive and non-sensitive lamellae provoking pain and moreover sinking or a rotation of the pedal bone in severe cases. This separation is permanent. The void between the lamella will be filled up with poor quality connective tissue and secondary horn (white line horn production). The white line will then be wider and weaker. The corium will be damaged to various degrees depending of the pedal bone displacement. The origin of the detachment is different in cattle but unfortunately the results are the same. It varies from focal hemorrhages to apical protrusion of the pedal bone. Subclinical rumen acidosis has been frequently associated as a causative agent of laminitis in cattle (Greenough, 2007). Toxin, endotoxin and inflammation by-products (Plaizier et al., 2008) produced by the rumen flora during ruminal acidosis might have a detrimental effect on the vascularisation of the foot or directly on the suspensory tissues of the pedal bone.

Table 2. Characteristics of the main causes of lameness in cattle.

	Lameness	Limb position	Pain (palpation)	Swelling	Specific physical exam	Specific test	Treatment/prevention
Stifle							
Septic joint	++++	Flexed	++++	+++	Joint palpation/find origin (lungs)	Arthrocentesis	Joint lavage, antibiotics 2 weeks
OCD	+	extension, circumduction	+	++	Examine controlateral stifle	Arthrocentesis, X-Ray	Correct diet, soft bedding
Hip							
Dorsal luxation	+++	Internal rotation hock	+	0	Abduction and palpation of greater trochanter (crepitation)	X-Ray	Slaughter
Ventral luxation	++++	Limb abducted downer	+	0	Trochanter medially displaced, excessive abduction	X-Ray	Euthanasia/emergency slaughter
Septic joint	++++	Toe touching	+	+/-	Abduction, flexion (pain) Find origin (lungs)	Arthrocentesis, X-Ray	Antibiotics for 2 weeks
Femoral head fracture	++	Greater trochanter higher	++	0	Abduction and palpation of greater trochanter (crepitation)	X-Ray	Euthanasia/emergency slaughter
Elbow							
OCD	++	Normal	+	+	Flexion/extension	Arthrocentesis, X-Ray	Correct diet, soft bedding
Septic joint	+++	Normal	++	++	Flexion/extension	Arthrocentesis, X-Ray	Antibiotics for 2 weeks
Ulnar fracture	+++	Dropped elbow	+++	+++	Olecranon palpation	X-Ray	Stall rest

Table 2 (follows). Characteristics of the main causes of lameness in cattle.

	Lameness	Limb position	Pain (palpation)	Swelling	Specific physical exam	Specific test	Treatment/prevention
Humerus							
Diaphyseal fracture	+++	Dropped elbow	+++	+++	Humerus palpation and abduction	X-Ray	2 months of stall rest (prognosis 50%) Emergency slaughter
Shoulder							
Septic joint	++++	Normal	+++	++	Joint palpation, flexion/extension	Arthrocentesis, X-Ray	Antibiotics for 2 weeks
OCD	++	Normal	+	+	Flexion/extension	Arthrocentesis, X-Ray	Correct diet, soft bedding
Foot							
Septic coffin joint	++++	Toe touching	++++	+++	Swelling/draining tract at the coronary band	Probe in the fistula, X-Ray	Amputation, joint resection
Toe ulcer/abscess	+++	High heels (overgrowth)	+++	0	Sole exam and hoof tester	Probe in a tract, X-Ray	Debridement Subtotal amputation
Footrot	++/+++	Toe touching	+++	++	Pastern is swollen, fever	Interdigital necrosis	Debridement, Short term antibiotics
Laminitis	+/+++	Abnormal stance	++	0	Hoof tester and sole examination	Longitudinal cut of the feet at autopsy	Correct diet, soft bedding
Septic fetlock	++++	Toe touching, flexed fetlock	++++	+++	Swelling/draining tract or laceration	Arthrocentesis, X-Ray	Joint lavage, antibiotics 2 weeks
Physitis	++	Tiptoes walking	++	++	Distal radial physis swelling	X-Ray	Correct diet, soft bedding

Table 2 (follows). Characteristics of the main causes of lameness in cattle.

	Lameness	Limb position	Pain (palpation)	Swelling	Specific physical exam	Specific test	Treatment/prevention
Carpus							
Septic joint	++++	Toe touching, flexed carpus	++++	+++	Swelling/draining tract or laceration	Arthrocentesis, X-Ray	Joint lavage, antibiotics 2 weeks
Hygroma	0	Normal	+/-	++	Soft, painless	Ultrasound	If many animals affected, verify stalls
physitis	++	Tiptoes walking	+	+	Distal metacarpal physis swelling	X-Ray	Correct diet, soft bedding
DJD	+/++	Flexed carpus	+	++	Bilateral carpal swelling in flexed position	Arthrocentesis, X-Ray	Soft bedding, slaughter
Hock							
Septic joint	++++	Toe touching, flexed tarsus	++++	+++	Swelling/draining tract or laceration	Arthrocentesis, X-Ray	Joint lavage, antibiotics 2 weeks
OCD	+	Extension	+	++	Often bilateral painless swelling	Arthrocentesis, X-Ray	Correct diet, soft bedding
Hygroma	0	Normal	+/-	++	Lateral soft swelling, painless	Ultrasound	If many animals affected, verify stalls
Gastrocnemius rupture	+++	Dropped hock/downer	+	++	Flexion of the hock with the stifle extended	Physical exam	Euthanasia/emergency slaughter
Peroneus rupture	++	Hyperextension hock	+/-	+/-	Complete extension of the hock with stifle extended	Physical exam	Stall rest

Using the oligofructose overload model, Dansher showed that in fact, there are clinical (weight shifting, solar hemorrhages) and histological changes at the lamellar level consistent with laminitis. However, it does not decrease the strength of suspensory tissue of the bovine claw (Danscher et al., 2010).

4.3.2 Osteochondrosis

Osteochondritis is a focal disturbance of the endochondral ossification for which the exact underlying disease mechanisms remain unknown. The consequence is an abnormal thickening of the cartilage known as cartilage retention. Evolution of the lesion is highly dependent of the type of forces applied to the dysplasic cartilage area. Fissures or fractures of the cartilage occur in areas subjected to shear forces. Those fractures and focal cartilage weakness can evolve to a complete separation of the cartilage from the underlying subchondral bone to form a typical osteochondritis dissecans lesion (OCD). Osteochondral fragments are formed when cartilage flaps do separate entirely. In contrast high compressive loading on dysplasic cartilage areas create cartilage infolding and resorption evolving to a subchondral bone cyst (SBC) (Ytrehus et al., 2007).

Predisposing factors are not well established. High energy and protein diet have been investigated and suspected as a cause of osteochondrosis (Jensen et al., 1981; Ytrehus et al., 2007; Tryon and Farrow, 1999). Animals on high intensity diet were more affected and the lesions more severe. Low concentration of calcium was also suspected. Other nutrients like phosphorus, vitamin A and D may play a role in osteochondrosis as well (Davies and Munro, 1999). Inheritance has been suspected in grazing beef cattle where affected animals, the males shared a common ancestral sire. However, the caloric intake rather than the concentration of any minerals is the most important predisposing factor among all the studies and all fast growing farm animals. The only exception is the bull where some research results are contradictory. American studies report a frequency of 8.5% for osteochondrosis lesion at the slaughter whereas the incidence seems higher in middle age bulls with 12% (Jensen et al., 1981). Lack of exercise was incriminated as a factor in one study. Based on the literature, osteochondrosis is more frequent in males. However, it is most likely over represented because only high genetic value bull will be examined and the condition reported (Trosltle et al., 1997). Hard flooring was shown to exacerbate methaphyseal osteochondrosis lesions in Holstein calves (White et al., 1984).

In cattle, joints commonly affected are the stifle and the tarsus. But osteochondrosis lesions have been diagnosed in the carpus, shoulder, and distal interphalangeal joint. In a study where 28,235 atlanto-occipital joints were examined, 3.8% had lesions compatible with osteochondrosis. In the same study, 8.5% of the 106 lame cattle had lesions of osteochondrosis mostly in the stifle (Jensen et al., 1981). Final diagnosis is often based on radiographic findings. Osteochondrosis dissecans, bone cysts and physitis can be observed.

4.3.3 Septic joint

Septic arthritis is the most common condition affecting the joints in cattle (Russell et al., 1982). It can be caused by a direct trauma to the articulation (primary), an adjacent infection to the articulation (secondary), a systemic infection (tertiary) (Desrochers, 2004). The distal limb, being less protected by soft tissue, is more exposed to external trauma especially if the environment favors it. Septic arthritis in cattle is of bacterial origin. Bacteria isolated from the articulations will depend of the cause of infection. The most common in adult are: Trueperella pyogenes, Escherichia coli, and other environmental bacteria. A retrospective study on bacterial culture of 172 cases of septic arthritis showed that Trueperella pyogenes was the most common bacteria isolated (35% of positive culture in young animal and 48% in adult) (Francoz et al., 2002). Sixty percent of cases had a positive culture. Cattle affected by Histophilus somnus as well as Mycoplasma sp may have more than one articulation infected.

If the incidence of septic joint increase in a herd without umbilical involvement, Mycoplasma and Histophilus somnus should be considered as a possible cause. Incidence of septic arthritis will increase in the presence of Mycoplasma pneumonia and mastitis in a herd (Houlihan et al., 2007). Arthritis was present in 25 of 54 calves with Mycoplasma bovis pneumonia in a feedlot (Gagea et al., 2006b). In feedlots of eastern France, Mycoplasma bovis was isolated in 8 of 9 operations included in a study on bovine respiratory disease. Mycoplasma bovis was isolated in brocho-alveolar lavage from 79% of normal calves and 82 of the sick calves (Arcangioli et al., 2008).

4.3.4 Physitis

It's a clinical syndrome of young rapidly growing animals affecting mainly the physeal regions of the appendicular skeleton. Affected animals will walk on toes therefore their heels will be higher with over worn toes. There is obvious

enlargement or flaring of the distal physeal area of the metacarpus or metatarsus in chronic cases. In a study looking at 46 12 month-old bulls clinical lameness, physitis was found in 34 animals (Dutra et al., 1999). Limb deformities will be present in severe cases (rotation, valvus or varus). At palpation, there is a hard swelling just proximal to the fetlock over the physis. It can be either septic or a type of osteochondrosis. Distal metacarpal or metatarsal physis are more commonly affected. However, distal radius could be affected as well. The pain engendered by the process is significant with consequences on appetite and growth rate.

Trauma or intrinsic abnormalities of focal blood supply of the cartilage could be at the origin of osteochondrosis lesion of the physis. Same etiologic factors as the osteochondritis dissecans have been incriminated. Housing on slatted floor was suspected in one study and confirm the theory of trauma to the physeal cartilage (Murphy et al., 1975). However, 2 out of 4 affected animals had a streptococcus isolated from the physis. In another study on calves raised on hard flooring, osteochondrosis lesions were found on lame calves (White et al., 1984). Harder floor exacerbated the clinical signs. Septic physitis is most likely secondary to a septicemia or local trauma. If no wound is observed than a remote infection origin must be suspected and investigated.

4.4 Risk factors

To evaluate the main LAD risk factors in the intensive beef cattle rearing, incidence of lameness in 10 farms were analyzed. The farms selected were located in the north of Italy and all of them import young cattle from France. Data were collect from each farm animal health database. According with farm management, once a day in the morning, a veterinary performs an animal health inspection inside each pen. In each pen, the herd veterinarian looked at each animal in order to detect any sign or symptom of pathology (lameness, swelling, asymmetry, abnormal stance). A more thorough physical examination was performed on affected animals and appropriated therapy was started. Animals with severe problems and deserving special care or prolonged therapy were moved to hospital pens. Lameness was defined by an abnormal gait and divided in 2 categories based on their location: arthropathies and foot diseases. Arthropathies were defined by any swelling located at the following joints: fetlock, carpus, tarsus and stifle. A more specific diagnosis could not be

attempted in this study considering the facilities and the management of the farms. The risk factors evaluated in this study were divided in 2 categories: animal and environment.

4.4.1 Factors related to the animal

To evaluate the animal related risk factors, data has been collected on about 18.000 animals from January 2010 to January 2011. In this farm, animals were kept in pens on concrete covered with wheat straw litter for 30 day after arrival. In this period they received a transition diet that gradually move to the fattening one characterized by high nutritional level. After 30 days, cattle are moved to fattening pens of 8-12 animals also in this case on straw bedding. Stables are covered and open on all 4 sides. For the animal we collected the following data: sex, breed and weight. The weight was subdivided in 4 categories based on the typical different typologies of newly received beef cattle imported from France. Male were not castrated.

Table 3 summarizes the results related to the signalment of the affected animals. Results show that there is a higher lameness incidence in males than in females. It is most likely related to the natural competing behavior of males and because males generally receive diets characterized by a higher nutritional level than female exposing them to higher risk of acidosis and therefore nervousness. European consumers ask for lean and tenderness beef, and considering the greater capacity and speed of fat deposition of female, their diets have lower energy content than males.

Breed is a risk factor for LAD incidence but there is a strong relationship with animal weight, It has been proved that some foot diseases have a partial genetic basis, and that certain morphological characteristics are associated with the development of lameness in dairy (McDaniel, 1997; Baggott and Russell, 1981).

To our knowledge these findings were not described in beef breeds. The high LAD incidence in Charolaise could be related to the weight and the size of these animals, factors that predispose to severe traumatic events during social fighting. Another factor could be the origin of animals; indeed Charolaise cattle generally come from flat pastures and in these circumstances joints are not adapted to intense solicitations or to sudden movements typically present on mountain pastures. We hypothesize that their limb conformation is not adapted for feedlot as in other breeds coming from uplands as Limousine or Aubrac.

Table 3. LAD incidence and animal signalment (Sgoifo Rossi, 2011).

Risk factors	Sex		Breed*			Weight			
	♂	♀	Lm	Ch	Cr	< 300	300-380	380-450	> 450
Number of animals	9,261	8,435	10,646	4,323	2,727	5,226	4,360	4,594	3,516
Average weight, kg	434 ± 52	285 ± 50	328 ± 82	443 ± 66	372 ± 70	254 ± 31	338 ± 24	416 ± 20	486 ± 31
LAD, %	3.97	0.42	2.11	3.83	2.03	0.45	1.38	4.09	3.83
Foot diseases, %	2.24	0.38	1.13	2.61	1.31	0.33	0.83	2.35	2.30
(% LAD)	(56)	(90)	(54)	(68)	(79)	(73)	(60)	(57)	(60)
Arthtopathy, %	1.73	0.04	0.98	1.22	0.72	0.12	0.55	1.74	1.53
(% LAD)	(44)	(10)	(46)	(32)	(21)	(27)	(40)	(43)	(40)
Problem cattle, %**	6.37	4.42	5.48	6.38	3.81	5.28	4.75	5.92	5.88
Foot diseases, %	25.64	1.07	7.54	19.56	16.34	4.35	14.49	33.82	33.34
Arthropathies, %	16.94	6.97	16.95	31.17	16.34	2.17	3.87	15.08	23.19

*Lm: limousine; Ch: charolaise; Cr: crossbreed

**cattle moved to hospital pen

Charolaise cattle have also a higher incidence of lameness due to nutritional causes, probably because those subjects have a higher feed intake than other breeds both in total volume per day and in volume per meal, with consequent higher risk of rumen acidosis. Whilst taking into account the importance of several environmental risk factors, several nutritional foot disease in newly received beef cattle could depend also by the dramatic change in the diet composition that occur between pasture, arrival and finishing diet and so it's important to implement an adequate nutritional management.

In the end, collected data show that LAD incidence is also higher among heavier animals at arrival.

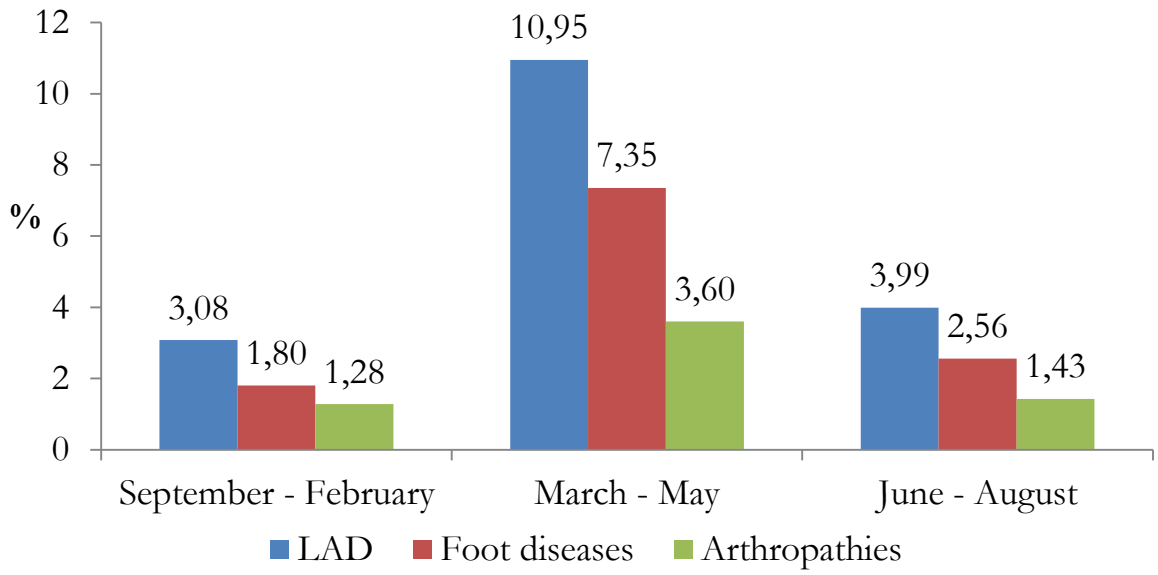
It could be caused by a higher social competitiveness during the adaptation period and to a higher protein and energetic concentration of diets administered to older and heavier cattle during not only adaptation but also during the following rearing phases.

4.4.2 Factors related to environment

To verify the effects of season as a risk factor for LAD, another study has been conducted in the previous farm (Figure 1). In spring time, LAD incidence was higher than in the other periods of the year. The increasing temperature that characterized Italian climate condition during spring time is certainly a factor that makes litter administration more complicated and in case of poor

management, bacteria proliferation and moisture can weaken foot tissues justifying the LAD increasing (Greenough, 2007).

Figure 1. LAD incidence and season (Sgoifo Rossi, 2011).



The lower incidence detected in summer is in contrast with that view, pointing out that other factors intervene in spring in increasing lameness susceptibility. In this period, in fact, temperature, humidity and day light conditions are ideal for fungi and mold development in hay and silage, increasing the risk of presence of mycotoxins. Mycotoxicosis, especially those supported by toxins produced by Fusarium fungi, interfering with ruminal microbial populations, can lead to a more or less severe ruminal acidosis with all the systemic effects that bring to laminitis (Sgoifo Rossi and Compiani, 2011). Furthermore, some cases of limb subcutaneous tissue diffuse edema caused by vasoactive mycotoxins, can be misinterpreted as arthritis and then LAD incidence could be overestimate. We think that this increase of lameness during spring in Italy is related to the raising of called cattle "repouse". Those animals would have spent the previous winter in stable in their country of origin and are imported older and heavier. It makes them at risk for LAD as explained earlier.

Among the environmental factors, an important role is certainly played by floor and in particularly by its hardness, abrasiveness and slipperiness. In Italy, beef cattle are frequently housed on the slatted floor and lameness are often associated with traumatic injuries as a result of mating and competitive behavior. Insufficient wear and overgrowth are observed on slatted floor. As a

consequence, the cattle are more prone to white line disease, sole ulcer and abscess (Greenough, 2007). If a concrete floor is covered with litter, it must be kept as dry as possible to avoid excessive pathogen bacterial growth like fusobacterium, spirochetes and dichelobacter. Among different bedding material, wheat straw has the highest insulating properties and good absorbing capacity. Sand and sawdust has higher absorbing capacity but very low insulating properties and moreover, high amounts of sawdust can increase irritation of upper airways (Midwest plan service, 1976; Panivivat et al., 2004).
In Table 4 are reported the results of LAD incidence in 5 different farms which differ mainly in the floor surface of fattening pens. Those farms imported young cattle from France and managed them as the first farm described above. Since floor type is certainly a LAD risk factor, in our study the type of surface was not strictly related to joint or foot diseases as expected. The incidence of foot diseases in litter housing was ranging from 24 to 65% of total LAD, incidence range very similar as observed on slatted floor (21 to 68%). Comparable trends were also recorded for arthropathies (litter: 35-76%; slatted: 32-79%). Even in this case, the association with other subjective risk factors or related to the environment, can influence LAD incidence.

Table 4. LAD incidence and floor type in 5 different beef cattle rearing in north of Italy between 2009 and 2010 (Sgoifo Rossi, 2011).

Farm	**1**	**2**	**3**		**4**	**5**
Number of animals	45,608	3,520	17,300	16,800	11,800	3,780
Floor	Litter	Litter	Litter	Slatted	Slatted	Slatted
LAD, %	1.19	3.31	3.82	2.89	2.80	2.97
Foot diseases, %	0.77	0.81	1.18	1.27	1.91	0.62
(% LAD)	(65)	(24)	(31)	(44)	(68)	(21)
Arthtopathy, %	0.42	2.5*	2.64	1.62	0.8	2.35**
(% LAD)	(35)	(76)	(69)	(56)	(32)	(79)

*40% traumatic injuries; 60% septic arthritis
**16% traumatic injuries; 84% septic arthritis

In addition to the type of floor, other environmental factors may increase the risk for LAD; safe handling facilities with adequate animal density per pen. Staff must be well trained to recognize not only sick animals but to understand the behavior of cattle. Sudden change of direction, strong competition between animals or confrontation with cattle increases the risk of injury (Greenough, 2007). In field condition is very difficult to evaluate how each environmental

factor could influence by itself the LAD morbidity, so we chose 3 different farms in the same area of North of Italy which imports same typology of animal but which differ in management level as reported in Table 5. In case of poor (farm 3) or fairly good (farm 2) management level, LAD incidence is higher than in very good managerial conditions (farm 1). Indeed, in farm 1, the density per pen is ideal (> 4.5 m2/head), each day is added bedding material, water troughs are proportional in number and size and the interaction between humans and animals aims to maximizing the animal quietness.

Table 5. LAD incidence and management in 3 different farms (Sgoifo Rossi, 2011).

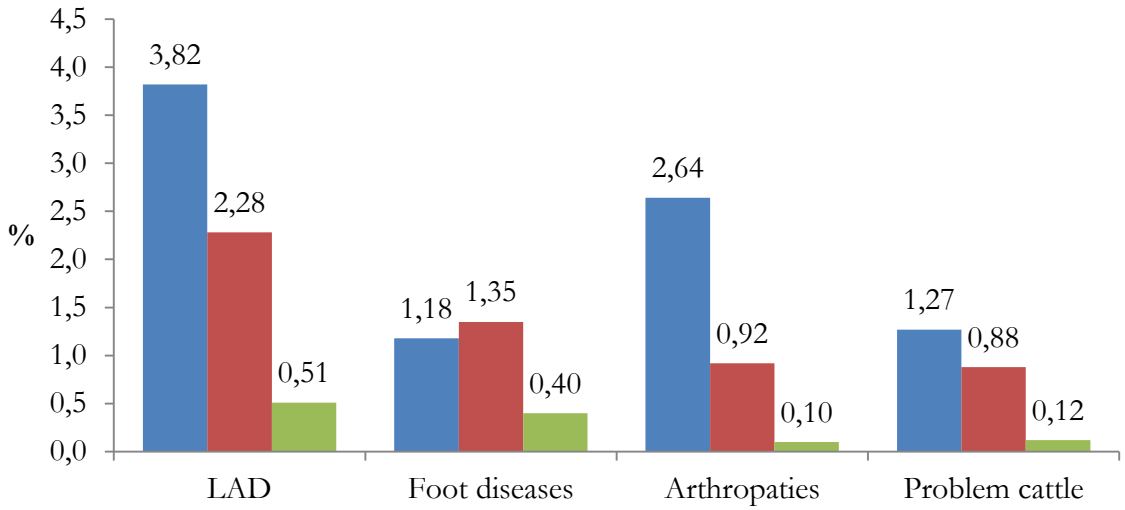
Farm	**1**	**2**	**3**
Management	Very good*	Fairly good**	Poor***
Number of animals	9,844	2,082	3,403
LAD, %	1.85	3.53	6.03
Foot diseases, %	0.24	0.88	3.46
(% LAD)	(13)	(25)	(57)
Arthtopathy, %	1.61	2.65	2.57
(% LAD)	(87)	(75)	(43)

*Very good: density >4.5 m^2/head, bedding straw added daily, water troughs with float valve, very good interaction between animals and humans, more than 5 dietary steps
**Fairly good: density 3.5-4.5 m^2/head, bedding straw added every 2 days, water troughs with float valve, very good interaction between animals and humans, 3 to 5 dietary steps
***Poor: density <3.5 m^2/head, bedding straw added every 5 days, nose-activated water troughs, poor interaction between animals and humans, 2 to 3 dietary steps

Management level was also evaluated in the same farm through the years in which there was a considerable effort to improve handling facilities, cattle comfort and operative procedures. The data collection on the farm represented in Figure 2 was over 10 years. It has a significant positive impact on the LAD incidence and a decrease on number of animals in hospital pen. From 1999 to 2011 were progressively implemented structure and management related procedures to optimize the production process throughout an overall reduction of health problems. For example, space availability per head was increased from 2.5 to 4.5 m2, in this condition, cattle can lay down more often. This probably causes less overload on claw and better rumination avoiding laminitis-related lameness. Grouping the newly received cattle started to be made with the objective to minimize competitive behaviors standardizing as possible animal weight and conformation. It was built a specific structure where carry out the

conditioning procedures in complete safety for animals and operators (vaccinations, antibiotic and antiparasite treatments, clipping, etc.). It was constantly carried out the quarantine and a proper feeding management for this period. Were installed ventilation and cooling devices. Staff was trained and every procedures were coded with the aim to avoid each stressful events in particular in the early stages of interaction with humans.

Figure 2. LAD incidence and management in the same farm through over 10 years (Sgoifo Rossi, 2011).



1999: density 2.5 m2/head, random grouping, very short quarantine, no conditioning structure, poor litter management, no cooling devices, not coded staff procedures, occasional feed and diet control

2006: density 3.5 m2/head, grouping on weight and conformation, short quarantine, conditioning procedures often in a specific structure, good litter management, no cooling devices, not coded staff procedures, occasional feed and diet control

2011: density 4.5 m2/head, grouping on weight and conformation, correct quarantine, conditioning procedures always in a specific structure, very good litter management, cooling devices, coded staff procedures, constant feed and diet control

Great importance as risk factor must also be attributed to animal nutrition, in particular to forced concentrates feeding, to ad libitum feed administration and then to full fermentation, to the correct diet making and distribution, and in the

end, to degradability and fermentability of diet components. All these aspects are closely related to ruminal acidosis, and thus to laminitis. Still today, the prevailing thought among experts is that nutritional issues are necessary but not sufficient to cause LAD (Brizzi, 2007).
However, Table 5 and Figure 2 show how a management aimed to reduce LAD and other health problems, shall also cover very careful nutritional aspects. Reach too quickly the finishing diet is possible but should be made through several intermediate steps to promote the correct animal and rumen microbial metabolic adaptation. In fact, sudden changes in diet composition contribute to promote metabolic disorders that can cause laminitis. Moreover, to avoid digestive problems and consequently nutritional based lameness, is fundamental the constant nutritional control, intended as precision in ingredients loading in mixing wagon, right particle size, unifeed homogeneity, appropriate integration of vitamins and minerals for each specific phase, and also attention to raw materials quality (Gremmels, 2008).

4.5 Discussion

The results of the studies reported above show that in Italian intensive beef cattle rearing, LAD is an important problem characterized by variable incidence and different risk factors compared to North American rearing. Incidence of LAD observed were significantly variable not only between farms but also between groups of cattle of the same farm but housed in different environmental conditions. The high incidence of lameness, makes it one of the major issues concerning cattle welfare (Shearer et al., 2013; Bruijnis et al. 2012, Greenough, 2007). Animals affected by foot pain show several postural changes and anomalies in locomotion, which tend to be more evident the greater the severity of lameness (Sprecher et al., 1997). Furthermore, a chronic painful condition, besides being very stressful, leads to a slow healing process, a reduction of feed intake and production performances, a weakening of heart and lungs activity and increases nervousness and associated diseases (i.e. frequent postural changes can lead to muscle weakness or joint injuries) (Whay, 2009).
Regarding risk factors, subject characteristics are very important. A male Charolaise has a higher weight at arrival, and is more predisposed to LAD. Floor is certainly a risk factor, but the right choice of which animal will be housed on slatted floor can strongly limit arthropathy incidence and a proper litter

management can prevent foot diseases. In addition to floor type, other livestock facilities and management can limit or promote LAD incidence and severity. For example, lower animal density per pen, a better staff training, cooling devices during hot periods and adequate structures or procedures for containment and handling, can limit the occurrence of traumatic injuries thanks to a reduction of cattle nervousness and competitive behaviors. Furthermore even feed quality control, a proper vitamins and minerals integration and the gradual transition from arrival to finishing diet, limit acidosis events and then laminitis. More LAD risks factors, as length and travel condition or bunk fighting, have to be evaluated in the future to improve preventing strategies in beef cattle rearing respecting the Italian particular situation.

4.6 Final consideration

A limit of the studies reported is certainly the lack in detection of lameness diagnosis and severity, but the monitoring process has been carried out faithfully reflecting what happens in almost all of the intensive beef production system. Even in case of great LAD morbidity, seldom in field conditions the real cause of lameness is clearly identified and probably often, occur diagnostic misinterpretations based only on visual inspection. With correct handling and containing facilities can be made a proper clinical examination of the affected limb. Furthermore, the use of additional diagnostic procedures and tools, i.e. centesis, x-ray or ultrasonography, can help and speed up the decision-making process not only about the fate of a specific lame animal but also to identify the cause behind of a widespread problem in the herd. In this way can be adopted specific preventing strategies in order to limit drugs administration, not essential in every case of lameness.

In conclusion, considering the multiple triggering (microbial, mechanical, nutritional, and genetic) and predisposing factors (subjective and environmental), the clinical condition of lameness in beef cattle could be considered a multifactorial complex syndrome.

4.7 References

Ahola, J. K., Foster, H. A., Vanoverbeke, D. L., Wilson, R. L., Glaze, J. B., Fife, T. E., Gray, C. W., Nash, S. A., Panting, R. R., Rimbey, N. R. (2011) Quality defects in market beef and dairy cows and bulls sold through livestock auction markets in the Western United States: II. Relative effects on selling price. *J. Anim. Sci.* 89(5):1484-1495.

Amory, J. R., Barker, Z. E., Wright, J. L., Mason, S. A., Blowey, R. W., Green, L. E. (2008) Associations between sole ulcer, white line disease and digital dermatitis and the milk yield of 1824 dairy cows on 30 dairy cow farms in England and Wales from February 2003-November 2004. *Prev. Vet. Med.* 83:381-391.

Arcangioli, M. A., Duet, A., Meyer, G., Dernburg, A., Bézille, P., Poumarat, F., Le Grand, D. (2008) The role of Mycoplasma bovis in bovine respiratory disease outbreaks in veal calf feedlots. *Vet. J.* 177:89-93.

Baggott, D. G., Russell, A. M. (1981) Lameness in cattle. *Br. Vet. J.* 137:113-132.

Barth, A. D., Waldner, C. L. (2002) Factors affecting breeding soundness classification of beef bulls examined at the Western College of Veterinary Medicine. *Can. Vet. J.* 43:274-284.

Brizzi, A. (2007) How to manage feeds for preparing efficient rations. *Informatore Agrario*. 63(38):45-48.

Brizzi, A. (2010) Evolution of digital diseases in cattle, structural research and functional trimming. Which future?. *Summa Animali da Reddito.* 5:38-45.

Bruijnis, M. R., Beerda, B., Hogeveen, H., Stassen, E. N. (2012) Assessing the welfare impact of foot disorders in dairy cattle by a modeling approach. *Animal* 6:962-970.

Bruijnis, M. R., Hogeveen, H., Stassen, E. N. (2013) Measures to improve dairy cow foot health: consequences for farmer income and dairy cow welfare. *Animal*. 7(1):167-175.

Cha, E., Hertl, J. A., Bar, D., Gröhn, Y. T. (2010) The cost of different types of lameness in dairy cows calculated by dynamic programming. *Prev. Vet. Med.* 97:1-8.

Church, T. L., Radostits, O. M. (1981) A retrospective survey of diseases in feedlot cattle in Alberta. *Can. Vet. J.* 22:27-30.

Collick, D. W., Ward, W. R., Dobson, H. (1989) Associations between types of lameness and fertility. *Vet. Rec.* 125:103-106.

Danscherm, A. M., Toelboell, T. H., Wattle, O. (2010) Biomechanics and histology of bovine claw suspensory tissue in early acute laminitis. *J. Dairy Sci.* 93:53-62.

Davies, I. H., Munro, R. (1999) Osteochondrosis in bull beef cattle following lack of dietary mineral and vitamin supplementation. *Vet. Rec.* 145:232-233.

Desrochers, A. (2004) Septic Arthritis. In: S.L. Fubini, N.G. Ducharme (ed.) Farm Animal surgery. Missouri: Saunders, pp 330-336.

Dutra, F., Carlsten, J., Ekman, S. (1999) Hind limb skeletal lesions in 12-month-old bulls of beef breeds. *Zentralbl Veterinarmed A.* 46:489-508.

Edwards, A. (1984) Preventing Toe Abscesses. In: Feedlot Management April, pp 39-42.

Enting, H., Kooij, D., Dijkhuizen, A. A., Huirne, R. B. M., Noordhuizen-Stassen, E. N. (1997) Economic losses due to clinical lameness in dairy cattle. *Livestock Production Science*. 49(3):259-267.

Fjeldaas, T., Nafstad, O., Fredriksen, B., Ringdal, G., Sogstad, A. M. (2007) Claw and limb disorders in 12 Norwegian beef-cow herds. *Acta Vet. Scand.* 49:24.

Francoz, D., Desrochers, A., Fecteau, G. (2002). A retrospective study of joint bacterial culture in 172 cases of septic arthritis in cattle. Proc. 20th Annual ACVIM Forum, 774.

Gagea, M. I., Bateman, K. G., Shanahan, R. A., van Dreumel, T., McEwen, B. J., Carman, S., Archambault, M., Caswell, J.L. (2006b) Naturally occurring Mycoplasma bovis-associated pneumonia and polyarthritis in feedlot beef calves. *J. Vet. Diagn. Invest.* 18:29-40.

Gagea, M. I., Bateman, K. G., van Dreumel, T., McEwen, B. J., Carman, S., Archambault, M., Shanahan, R. A., Caswell, J. L. (2006a) Diseases and pathogens associated with mortality in Ontario beef feedlots. *J. Vet. Diagn. Invest.* 18:18-28.

Greenough, P. R. (2007) Bovine laminitis and lameness: a hands-on approach. Philadelphia: Sauders, Elsevier.

Gremmels, J. F. (2008) The role of mycotoxins in the health and performance of dairy cows. *Vet. J.* 176:84-92.

Griffin, D., Perino, L. J., Hudson, D. (1993) Feedlot Lameness. In: University of Nebraska Lincoln Extension: University of Nebraska-Lincoln, 6.

Heinola, T., Jukola, E., Nakki, P., Sukura, A. (2006) Consequences of hazardous dietary calcium deficiency for fattening bulls. *Acta Vet. Scand.* 48:25.

Hernandez, J., Shearer, J. K., Webb, D. W. (2001) Effect of lameness on the calving-to-conception interval in dairy cows. *J. Am. Vet. Med. Assoc.* 218:1611-1614.

Hernandez, J., Shearer, J. K., Webb, D. W. (2002) Effect of lameness on milk yield in dairy cows. *J. Am. Vet. Med. Assoc.* 220:640-644.

Hewicker-Trautwein, M., Feldmann, M., Kehler, W., Schmidt, R., Thiede, S., Seeliger, F., Wohlsein, P., Ball, H. J., Buchenau, I., Spergser, J., Rosengarten, R. (2002) Outbreak of pneumonia and arthritis in beef calves associated with Mycoplasma bovis and Mycoplasma californicum. *Vet. Rec.* 151:699-703.

Houlihan, M. G., Veenstra, B., Christian, M. K., Nicholas, R., Ayling, R. (2007) Mastitis and arthritis in two dairy herds caused by Mycoplasma bovis. *Vet. Rec.* 160:126-127.

Jensen, R., Lauerman, L. H., Park, R. D, Braddy, P. M., Horton, D. P., Flack, D. E., Cox, M. F., Einertson, N., Miller, G. K., Rehfeld, C. E. (1980) Limb arthropathies and periarticular injuries in feedlot cattle. *Cornell Vet.* 70:329-343.

Jensen, R., Park, R. D., Lauerman, L. H., Braddy, P. M., Horton, D. P., Flack, D. E., Cox, M. F., Einertson, N., Miller, G. K., Rehfeld, C. E. (1981) Osteochondrosis in feedlot cattle. *Vet. Pathol.* 18:529-535.

Lischer, Ch. J., Ossent, P., Raber, M., Geyer, H. (2002) Suspensory structures and supporting tissues of the third phalanx of cows and their relevance to the development of typical sole ulcers (Rusterholz ulcers). *Vet. Rec.* 151:694-698.

McDaniel, B. T. (1997) Genetics of conformation. In: P.R. Greenough (ed) Lameness in Cattle, Philadelphia, W. B. Saunders, 75-78.

Midwest plan service (1976) Livestock waste facilities handbook. Iowa State University, 6.

Miskimins, D. W. (2002) Predominant causes of lameness in feedlot lameness and stocker cattle. Proc: 12th International Symposium on Lameness in Ruminants, Orlando, Shearer J. K., Orlando, 147-151.

Murphy, P. A., Weavers, E. D., Barrett, J. N. (1975) Epiphysitis in beef cattle fattened on slatted floors. *Vet. Rec.* 97:445-447.

Ossent, P., Lischer, C. (1998) Bovine laminitis: the lesions and their pathogenesis. *In Practice* 20:415-427.

Panciera, R. J., Confer, A. W. (2010) Pathogenesis and pathology of bovine pneumonia. *Vet. Clin. North Am. Food Anim. Pract.* 26(2):191–214.

Panivivat, R., Kegley, E. B., Pennington, J. A., Kellogg, D. W., Krumpelman, S. L. (2004) Growth performance and health of dairy calves bedded with different types of materials. *J. Dairy Sci.* 87:3736-3745.

Persson, Y., Soderquist, L., Ekman, S. (2007) Joint disorder; a contributory cause to reproductive failure in beef bulls. *Acta Vet. Scand.* 49:31.

Plaizier, J. C., Krause, D. O., Gozho, G. N., McBride, B. W. (2008) Subacute ruminal acidosis in dairy cows: the physiological causes, incidence and consequences. *Vet. J.* 176:21-31.

Project TADHH (2012) The Alberta Dairy Hoof Helath Project Hoof Health Database.

Reiland, S., Stromberg, B., Olsson, S. E., Dreimanis, I., Olsson, I. G. (1978) Osteochondrosis in growing bulls. Pathology, frequency and severity on different feedings. *Acta Radiol.* Suppl. 358:179-196.

Roeber, D. L., Mies, P. D., Smith, C. D., Belk, K. E., Field, T. G., Tatum, J. D., Scanga, J. A., Smith, G. C. (2001) National market cow and bull beef quality audit-1999: a survey of producer-related defects in market cows and bulls. *J. Anim. Sci.* 79:658-665.

Russell, A. M., Rowlands, G. J., Shaw, S. R., Weaver, A. D. (1982) Survey of lameness in British dairy cattle. *Vet. Rec.* 111:155-160.

Sagliyan, A., Gunay, C., Han, M. C. (2010) Prevalence of lesions associated with subclinical laminitis in dairy cattle. *Isr. J. Vet. Med.* 65:27-33.

Sgoifo Rossi, C. A. (2011) Importanza delle patologie agli arti nell'allevamento del vitellone da carne. Proc: XIV Congresso Internazionale SIVAR, Palazzo Trecchi, Cremona Italy, 6-7 maggio 2011.

Sgoifo Rossi, C. A., Compiani, R. (2011) Bovine mycotoxicosis. *Large Anim. Rev.* 17(6):237-245.

Shearer, J. K., Stock, M. L., Van Amstel, S. R., Coetzee, J. F. (2013) Assessment and Management of Pain Associated with Lameness in Cattle. *Vet. Clin. North Am. Food Anim. Pract.* 29:135-156.

Sprecher, D. J., Hostetler, D. E., Kaneene, J. B. (1997) A lameness scoring system that uses posture and gait to predict dairy cattle reproductive performance. *Theriogenology*. 47:1179-1187

Stokka, G. L., Lechtenberg, K., Edwards, T., MacGregor, S., Voss, K., Griffin, D., Grotelueschen, D. M., Smith, R. A., Perino, L. J. (2001) Lameness in feedlot cattle. *Vet. Clin. North Am. Food Anim. Pract.* 17:189-207.

Townsend, H. G., Meek, A. H., Lesnick, T. G., Janzen, E. D. (1989) Factors associated with average daily gain, fever and lameness in beef bulls at the Saskatchewan Central Feed Test Station. *Can. J. Vet. Res.* 53:349-354.

Trostle, S. S., Nicoll, R. G., Forrest, L. J., Markel, M. D. (1997) Clinical and radiographic findings, treatment, and outcome in cattle with osteochondrosis: 29 cases (1986-1996). *J. Am. Vet. Med. Assoc.* 211:1566-1570.

Tryon, K. A., Farrow, C. S. (1999) Osteochondrosis in cattle. *Vet. Clin. North Am. Food Anim. Pract.* 15:265-274.

Weisbrode, S. E., Monke, D. R., Dodaro, S. T., Hull, B. L. (1982) Osteochondrosis, degenerative joint disease, and vertebral osteophytosis in middle-aged bulls. *J. Am. Vet. Med. Assoc.* 181:700-705.

Whay, H. R. (2009) A decade of pain: a look back over ten years of discovery about pain associated with lameness in cattle. In: Proceedings of Cattle Lameness Conference, School of Veterinary Medicine and Science University of Nottingham, Leicestershire, 19-22.

White, S. L., Rowland, G. N., Whitlock, R. H. (1984) Radiographic, macroscopic, and microscopic changes in growth plates of calves raised on hard flooring. *Am. J. Vet. Res.* 45:633-639.

Ytrehus, B., Carlson, C. S., Ekman, S. (2007) Etiology and pathogenesis of osteochondrosis. *Vet. Pathol.* 44:429-448.

Zecconi, A., Sturlesi, N., Tarantino, S. (2012) Risk factors for hoof diseases. *Informatore Agrario*. 68:68-70.

CHAPTER 5

Health and growth effects of dietary supplementation of selenium in organic and inorganic form to newly received beef cattle

5. Health and growth effects of dietary supplementation of selenium in organic and inorganic form to newly received beef cattle

AUTHORS: C.A. Sgoifo Rossi*, R. Compiani*, G. Baldi*, M. Muraro**, R. Rossi*, G. Pastorelli*, C. Corino*, V. Dell'Orto*
**Department of Health, Animal Science, and Food Safety (VESPA), University of Milan*
**Veterinary of Consorzio Agrario Lombardo Veneto, Verona, Italy*

5.1 Abstract

The effects on health and growth performance of two different sources of selenium administered to newly received beef cattle were evaluated in a 54 days field trial. 228 Limousine x Charolaise crossbreed bullocks (average age: 13 ± 1 months; live weight: 374.84 ± 29.43 kg) imported from France to an Italian fattening unit were enrolled in the study and monitored for the entire adaptation phase. At arrival, animals were vaccinated, treated for internal and external parasites and received a preventive antibiotic mass treatment because considered at high risk to develop respiratory diseases. Animals were housed on concrete floor covered by straw litter and provided ad libitum access to water, hay for the first 5 days and a specific adaptation diet formulated to meet or exceed nutritional requirements. Experimental groups diets were different only with regard to mineral and vitamin mix that were formulated with the aim to provide 3 mg of selenium per day from different sources (Control: sodium selenite (NaSe); Treatment: selenised yeast (Se-Y)). At experimental days 0, 19 and 54, animals were weighted individually to evaluate ADG, and blood samples were collected to evaluate serum selenium content, neutralizing antibody levels, serum bactericidal activity and total antiradical activity of whole blood and red blood cells. Treatment positively affected serum selenium content proving that organic sources of this trace mineral are characterized by higher bio-availability. Se-Y supplemented bullocks have greater ADG as a consequence of a lower incidence of respiratory diseases (BRD). BRD affected animals in Se-Y sub-group had a better recover after illness period since their ADG was higher than in Na-Sa supplemented sick animals. The higher level of circulating selenium since the first days after arrival have led Se-Y bullocks to a better recover after transport stress. Se-Y group has a better immune-reaction after exposure to the vaccinal

antigen and higher blood total antiradical activity. In the present experimental condition, the supplementation of 3 mg of selenium from organic source respect inorganic one, led to the improvement of immunity and antioxidant ability of newly received beef cattle. The higher bio-availability of selenised yeast is likely able to help animals to better and quickly recover after transport stress and illness events. The improvement of immunity and antioxidant ability reduced BRD morbidity promoting better growing performance.

5.2 Introduction

Selenium (Se) is an essential trace element for humans and livestock. Because in the most intensive agricultural areas of the world its content in soil is quite low (Oldfield, 2002; Dargatz and Ross, 1996), Se content in feed crops is highly variable and to fulfill cattle demand is necessary to supplement it (NRC, 2000). Se supplements are inorganic mineral salts, such as sodium selenite or selenate, or organic forms such as selenium enriched yeast. Several surveys on dairy (Ceballos et al., 2009) and on beef (Pehrson et al., 1989; Nicholson et al., 1991; Gunter et al., 2003; Juniper et al., 2008; Cozzi et al., 2011), showed that the bioavailability and biopotency of Se from organic sources was higher than that from inorganic ones. Se ability to improve immune response is already known for decades (Sheffy and Schultz,1979; Rooke et al., 2004) as its essential role in seleno-proteins composition like glutathione peroxidase enzyme which has important antioxidant activities (Rotruck et al., 1973; Fairweather-Tait et al., 2010) destroying free radicals (MacPherson, 1994) and protecting tissues against oxidative damage (Awad et al., 1994; Levander, 1986). Reactive oxygen species and free radicals are a natural result of the body's normal metabolic activity and in case of excessive stress can occur an over production of these free radicals negatively affecting health (McCord, 2000). One method to evaluate total antioxidant activity is the KRL (Kit Radicaux Libres) biological test that evaluates the antioxidant status of an organism by testing the antioxidant defense system of both plasma and red blood cells (RBC) (Prost, 1992). The intensive beef production system is mainly based on fattening, most of the time, light and not fully immune-competent very young calves moved from their origin farm to very often quite far fattening facilities, and therefore inevitably subject to a stressful transport and adaptation to new rearing environment and management. Therefore, the objective of this experiment was to evaluate the effects of Se

dietary supplementation from organic and inorganic sources, on immune response, antioxidant abilities and growth performance of newly received beef cattle imported from France to an Italian fattening facilities.

5.3 Materials and Methods

5.3.1 Animals, management and diet

Animal care and treatment were in accordance with the European Community 1986 guidelines n.609 approved by the Italian Ministry of Health. The experiment was carried out in a commercial fattening operation located in the north of Italy that was willing to participate and formally consented to conduct the research. A total of 228 Limousine x Charolaise crossbreed bullocks of 13 ± 1 months of age and average live weight of 374.84 ± 29.43 kg imported from France were enrolled in the study and monitored for the entire adaptation phase for a period of 54 days. At arrival (day 0), animals were vaccinated against bovine herpesvirus-1 (BHV1; booster dose at day 19), parainfluenza-3, bovine respiratory syncytial virus, bovine viral diarrhea and Mannheimia haemolytica, and treated for internal and external parasites with ivermectin and clorsulon at recommended dose. Furthermore, because of considered at very high risk for bovine respiratory disease (BRD) based on a risk assessments system proposed by Sgoifo Rossi et al. (2013), a preventive mass treatment with tulathromycin (1 ml/40 kg of live weight – Draxxin®, Zoetis) was performed. Bullocks were stratified by live weight and housed in 38 pens of 6 animals each. Pens had a concrete floor covered by straw litter with space allowance of 3,5 m2/animal and a manger space of 0.65 m/animal. Animals were provided ad libitum access to water, hay for the first 5 days and a specific adaptation diet formulated to meet or exceed NRC (2000) nutritional requirements. The composition of adaptation diet on as fed basis was: 40.0% corn silage 33% DM; 20.0% corn meal; 10.0% dry beet pulp; 10.0% wheat straw; 8.2% wheat bran; 5.0% soybean meal 44% CP; 5.0% sunflower meal 28% CP; 0.8% calcium carbonate; 0.5% sodium bicarbonate; 0.3% sodium chloride; 0.2% trace mineral and vitamin supplement (on dry matter basis: 0.88 UFV; 12.72% crude protein; 2.52% ether extract; 2.91% sugar; 39.73% NDF; 22.09% ADF, 28.85% starch; 0.83% Ca; 0.41% P; 7.23% ash).

Experimental groups diets were different only with regard to mineral and vitamin mix that were formulated with the aim to provide 3 mg of selenium per

day per animal from different sources. Selenium treatments consisted in inorganic source as sodium selenite (NaSe) and organic as selenised yeast (Se-Y) produced by a specific strain of Saccharomyces cerevisiae CNCM-I3399 (Selsaf®, Lesaffre, Italy).

5.3.2 Measurements

Individual body weight was recorded at arrival (day 0), at vaccine booster administration (day 19) and at the end of the adaptation period (day 54). Average daily gain (ADG) was measured by dividing the difference between final and initial live weight by the number of days on feed. Dry matter intake (DMI) was recorded (daily) by weighing the feed distributed and the residue in the manger 24 h later before the further administration. Feed conversion rate (FCR) was calculated by dividing average DMI by the mean ADG. Animal health evaluation during the experiment was both clinical than analytical. Bullocks were monitored twice a day by a veterinarian to early identify possible affection and in particular BRD, major health problem in beef cattle adaptation phase (Panciera and Confer, 2010).

Table 5. Clinical criteria of bovine respiratory disease (Baggott et al., 2011).

Depression score		**Respiratory character score**	
0	Normal: nothing unusual in the animal's attitude	0	Normal: no abnormal respiratory signs present. Respiratory rate and effort are appropriate for the environment
1	Mild depression: somewhat slow coming to the feed bunk, but did eat	1	Mild respiratory distress: serous and/or slight mucous nasal or ocular discharge and/or cough
2	Moderate depression: slight drooping of the head/ears, reluctant to move about, reluctant to come to feed	2	Moderate respiratory distress: mucopurulent or copious mucous nasal or ocular discharge and/or increase in respiratory rate or effort
3	Severe depression: pronounced head/ear drooping; very reluctant move	3	Severe respiratory distress: marked increase in respiratory rate or effort including one or more of the following: open-mouth breathing, abdominal breathing or head extended
4	Moribund (recumbent)		

Therefore, bullocks were diagnosed with BRD if they fulfilled the clinical criteria reported in Table 1, and subjected to appropriate therapy in case of depression score >0, respiratory character score >0 and rectal temperature ≥40.0°C.Animals diagnosed with BRD received two doses of florfenicol (1 ml/ 15 of live weight - Nuflor®, MSD Animal Helath) 48 hours apart. From 20 animals for each experimental group, at day 0, 19 and 54, blood samples were collected by jugular venipuncture into 10 ml EDTA tubes and 10 ml no additive tubes for KRL immediate whole blood assay as described later. Others blood samples collected into 10 ml no additive tubes were centrifuged (3000×g for 10 min at 4°C) to obtain serum, which were aliquoted into two 2 mL vials and stored frozen (−20°C) until analyzed for Se content, titration of antibodies against BHV1 by serum neutralization test and serum bactericidal activity.

5.3.3 Chemical analysis

Samples of the experimental diet were collected every two weeks and chemically analyzed for DM, CP, ether extract, starch and ash according to the methods of the Association of Official Analytical Chemists (AOAC, 1990). Neutral-detergent fibre analysis of the same samples was conducted according to VanSoest et al. (1991). The net energy content of the diet measured in Unité Fouragére Viande (UFV) units was calculated using for all feed ingredients the reference values reported by the Institut National de la Recherche Agronomique (INRA, 1988). Selenium concentration of feed and serum samples was determined using fluorometric methodology according to the procedure reported by AOAC (1990). BHV1 serum neutralization test was performed according to OIE Manual of diagnostic tests and vaccines for terrestrial animals (OIE, 2010). Neutralizing antibody levels were measured against the homologous vaccine virus. Antibodies were titrated by the constant virus varying serum dilution from ½ onwards. Before statistical analysis, the results of the neutralizing antibody titres were submitted to the transformation: log(1/x), where x was the serum dilution. Bacteriological assay of serum bactericidal activity was performed by a turbidometric test. Serum bactericidal activity ≥90% was considered a limit value for healthy cattle aged ≥6 months (Amadori et al., 1997). The total antiradical activity of whole blood and RBC for each bullocks was evaluated using KRL biological test (Laboratoires Spiral, France). The principle of the KRL test is to submit whole blood and RBC to thermo-controlled free radical aggression in order to mobilize all families of any free

radical scavengers present in the blood to neutralize the oxidation processes (Girodon et al., 1997; Stocker et al., 2003). All the sample chemical and enzymatic antioxidant systems, were triggered to protect cells integrity until lysis. Whole blood and RBC samples were submitted in an isotonic saline solution to organic free radicals produced at 37°C under air atmosphere from the thermal decomposition of a solution of 2.2´-azobis (2-amidinopropane) dihydrochloride (AAPH) (Kirial International, Dijon, France). Haemolysis was recorded using a 96-well microplate reader by measuring the optical density decay at 450 nm. For each well, absorbance measurements were performed 75 times, once every 150 seconds. Results were expressed as the time required to reach 50% of maximal haemolysis (half-haemolysis time - HT50 - in minutes), which refers to the whole blood resistance to free-radical attack. Intra and inter-assay coefficients of variation of the KRL test were 2.5% and 4%, respectively.

5.3.4 Statistical analysis

All statistical analyses were performed using IBM SPSS 21.0 for Windows (IBM Corporation, Armonk, New York, USA). Descriptive statistics are expressed as the mean (±SD). About animal live weight, to take account of replications the experimental groups were compared using a GEE (generalized estimating equation), in which the dependent variable (weight) had a normal distribution and an identity link function was used. Goodness of fit was assessed using a quasi-likelihood under independence model criterion (QIC). The threshold for statistical significance was considered to be $p<0.05$.

5.4 Results and Discussions

BRD incidence tended to be lower ($P=0.061$) in Se-Y group than in NaSe during the trial period corresponding to adaptation phase (Tab. 2). Se-Y supplemented bullocks have also greater ADG ($P<0.01$) (Tab. 2). This last finding is likely a consequence of a lower incidence of BRD in Se-Y group. During the experimental period no other health problems except for BRD have arisen, no further relapse events were recorded, there was no mortality and no animals were excluded from the trial because moved to infirmary pens. As reported in Tab. 2, BRD affected animals of both experimental groups had worse ADG ($P<0.001$) than healthy because of low feed intake during illness period in agreement with several authors (Sowell et al., 1999; Buhman et al., 2000). The

higher BRD incidence in Na-Se group can explain the lower DMI (P<0.05) and higher FCR (P<0.05) reported for this experimental group (Tab. 2). After recovering from BRD, beef cattle may experience a compensatory growth gaining 11% more weight than healthy and eating 0.3 kg/d less DM (Jim et al., 1993). Although, in the present study weight loss during the days of sickness was not recovered probably due to the short period of investigation. An effective compensatory growth can occur in longer-term study (Montgomery et al., 2009; Babcock et al., 2009; Holland et al., 2010) but even in these cases certain animal types are not able to completely fulfill the growth gap (Fucci et al., 2012; Gifford et al., 2012).

Table 6. Growth performance and BRD incidence.

Group	N	Weight, kg			ADG, kg/d			DMI, kg	FCR	BRD incidence, %
		0	19	54	0-19	19-54	0-54			
NaSe	120	381,20	401,69	452,66	1,08	1,46	1,32	8,9	6,8	41,66
		±30,22	±33,04	±37,38	±0,58	±0,45	±0,37			
Se-Y	108	367,83	390,00	447,77	1,17	1,65	1,48	9,3	6,3	34,26
		±26,99	±29,54	±35,18	±0,65	±0,43	±0,41			
Healty	141	370,78	393,72	450,05	1,21	1,61	1,47			
		±29,64	±31,98	±35,95	±0,61	±0,43	±0,39			
BRD	87	381,50	400,08	450,79	0,98	1,45	1,28			
		±28,01	±31,55	±37,22	±0,60	±0,47	±0,38			

Table 7. Growth performance in relation to health status.

Health status	Experimental group	n	Weight, kg			ADG, kg/d		
			0	19	54	0-19	19-54	0-54
Healty	NaSe	70	384,86	410,41	465,04	1,35	1,56	1,48
			±33,27	±33,56	±36,74	±0,43	±0,36	±0,31
	Se-Y	71	367,32	393,72	454,13	1,39	1,73	1,61
			±27,23	±28,11	±32,97	±0,56	±0,38	±0,36
BRD	NaSe	50	375,98	389,22	434,96	0,70	1,31	1,09
			±24,63	±28,20	±30,85	±0,55	±0,52	±0,34
	Se-Y	37	368,81	382,86	435,57	0,74	1,51	1,24
			±26,87	±31,28	±36,50	±0,62	±0,50	±0,39

Table 8. Results of blood analysis.

Parameters	Day	Na-Se	Se-Y
Serum Se (mg/L)	0	0,111 ± 0.004	0,112 ± 0.005
	19	0,112 ± 0.008	0,123 ± 0.006
	54	0,115 ± 0.008	0,126 ± 0.002
Neutralizing antibody titres (log)	0	0.00 ± 0.00	0.00 ± 0.00
	19	0.54 ± 0.32	0.78 ± 0.37
	54	1.10 ± 0.14	1.42 ± 0.37
Serum bactericidal activity (%)	0	89.47 ± 4.55	89.67 ± 6.37
	19	91.47 ± 2.33	92.60 ± 0.74
	54	92.33 ± 1.18	93.40 ± 0.83
Total blood KRL (T1/2 min)	0	152,58 ± 15.36	152,86 ± 16.92
	19	153,61 ± 8.77	163,13 ± 11.41
	54	158,88 ± 9.20	168,69 ± 8.63
Red cells KRL (T1/2 min)	0	118,08 ± 15.78	118,29 ± 9.53
	19	127,91 ± 16.37	132,85 ± 8.48
	54	147,96 ± 9.17	156,82 ± 8.38

In Tab. 3 are reported average live weights and ADG according to experimental groups but also according to animal health status. ADG of BRD affected animals in Se-Y sub-group was higher than in Na-Sa supplemented sick animal ($P<0.001$). This finding show that the higher bioavailability of selenium in Se-Y fed bullocks can leads to a better recover after illness period. This hypothesis is supported by the higher total blood and serum selenium content found in Se-Y supplemented bullocks than in Na-Sa group (Tab. 3).

Furthermore, even the ADG of Se-Y healthy animal was better than Na-Se healthy bullocks ($P<0.001$). An improvement of growth performance thanks to the strengthening of animal immunocompetence through selenium supplementation has already been suggested by several authors (Swecker et al., 1989; Nicholson et al., 1991). The higher level of circulating selenium since the first days after arrival have led Se-Y bullocks to a better recover after transport stress. Indeed, serum selenium content statistically increased ($P<0.001$) more in Se-Y group than in Na-Se after arrival at the fattening facility, according to levels reported in literature (Nicholson et al., 1991; Richards eta al., 2011).

Se-Y group has a better immune-reaction after exposure to the vaccinal antigen, in particular after booster administration performed at day 19 ($P<0.0001$). Considering that all the animals enrolled in the trial were not previously

vaccinated or affected by BHV1 as their neutralizing antibody level at arrival was 0, the finding of higher ($P<0.0001$) neutralizing BHV1 antibody levels found in Se-Y group can be explained by a better reaction to vaccination likely connected to the higher selenium bioavailability. Swecker et al. (1989), reported that a blood selenium concentrations of at least 0.1 mg/L are considered necessary for optimal antibody production in weaned calves

Treatment did not affected serum bactericidal activity. Serum bactericidal activity is a marker of the competence of not specific immunity and is linked to complement system and natural antibody to inhibit the activity of some bacterial strains characterized by low pathogenicity (Amadori et al, 2002). In physiological conditions bovine serum is characterized by bactericidal activity greater than 90%, value very closed to those of the animals of both experimental groups.

The KRL test showed an higher ($P<0.05$) blood total antiradicalic activity in Se-Y group than Na-Se supplemented cattle, while no differences were observed in the antiradical activity of the RBC between the two experimental groups. As recently observed, KRL may have effectiveness for assessing antioxidant activity of dietary fat and water soluble antioxidants fed to pigs (Rossi et al., 2013). No previous study reported the oxidative status in cattle measured as total antiradical activity. Data of the present study indicate that KRL test is able to discriminate dietary treatment with different sources of Selenium. The increase in blood total antiradical activity is probably related to the major adsorption and bioavailability of SE-Y. In fact, as observed in the present study, serum selenium concentrations are greater for animals fed Se-Y compared to Na-Se, in agreement with previous studies in dairy cows (Weiss, 2005; Weiss and Hogan, 2005). Selenium is a component of the selenoproteins that include glutathione peroxidase and thioredoxin reductase which are important components of antioxidant system (Andrieu, 2008). Dietary Se-Y supplementation is able to improve antioxidant status in young calves in a stressful conditions, such as transport and adaptation to new environmental conditions. In fact in a stressful period the rate of ROS production can exceed the amount of neutralization by the antioxidant system and can lead to oxidative damage of lipids, carbohydrates, and proteins within cells (Miller et al., 1993).

5.5 Final consideration

In the present experimental condition, the supplementation of 3 mg of selenium from organic source respect inorganic one, led to the improvement of immunity and antioxidant ability of newly received beef cattle. The higher bio-availability of selenised yeast is likely able to help animals to better and quickly recover after transport stress and illness events. The improvement of immunity and antioxidant ability reduced BRD morbidity promoting better growing performance.

5.6 References

Amadori M., I. L. Archetti, M. Frasnelli, M. Bagni, E. Olzi, G. Caronna, M. Lanteri (1997) An Immunological Approach to the Evaluation of Welfare in Holstein Frisian cattle. *Vet Med* B 44:321-327).

Andrieu, S. (2008) Is there a role for organic trace element supplements in transition cow health? *Vet. J.* 176:77-83.

Association of Official Analytical Chemists (1990) Official methods of analysis, 15th edition. AOAC, Washington, DC, USA.

Awad, J. A. ; Morrow, J. D. ; Hill, K. E. ; Roberts, L. J., II ; Burk, R. F. (1984) Detection and localization of lipid peroxidation in selenium- and vitamin E-deficient rats using F 2-isoprostanes. Journal of Nutrition Volume: 124 Issue: 6 Pages: 810-816.

Babcock A.H., White B J., Dritz S.S., Thomson D.U., Renter D. G. (2009) Feedlot health and performance effects associated with the timing of respiratory disease treatment. *J. Anim. Sci.,* vol. 87:314–327.

Baggott D., Casartelli A., Fraisse F., Manavella C., Marteau R., Rehbein S., Wiedemann M., Yoon S. (2011) Demonstration of the metaphylactic use of gamithromycin against bacterial pathogens associated with bovine respiratory disease in a multicentre farm trial. *Vet. Rec.,* vol. 168(9):241-245.

Buhman MJ, Perino LJ, Galyean ML, Wittum TE, Montgomery TH, Swingle RS. (2000) Association between changes in eating and drinking behaviors and respiratory tract disease in newly arrived calves at a feedlot. *Am J Vet Res* 61:1163–1168

Ceballos A, Sánchez J, Stryhn H (2009) Meta-analysis of the effect of oral selenium supplementation on milk selenium concentration in cattle. *J Dairy Sci* 92:324–342

Cozzi G., P. Prevedello, A. L. Stefani, A. Piron, B. Contiero, A. Lante, F. Gottardo and E. Chevaux (2011) Effect of dietary supplementation with different sources of selenium on growth response, selenium blood levels and meat quality of intensively finished Charolais young bulls. *Animal* 5:1531-8.

Dargatz DA, Ross PF (1996) Blood selenium concentrations in cows and heifers on 253 cow-calf operations in 18 states. *J Anim Sci* 74:2891–2895

European Communities Council (1986) Council Directive of 24 november 1986 on the approximation of laws, regulations, and administrative provisions of the Member States regarding the protection of animals used for experimental and other scientific purposes, 86/609/EEC. In: Official Journal, L 358, 18/12/1986, pp 1-28.

Fairweather-Tait, S.J., Collings, R., Hurst, R., (2010) Selenium bioavailability: current knowledge and future research requirements. *Am. J. Clin. Nutr.* 91, 1484S–1491S.

Fucci D, Compiani R, Baldi G, Sgoifo Rossi CA. (2012) Incidence of respiratory diseases and growth performance of high risk BRD newly received beef cattle treated at arrival. *Lar Anim Rev* 18(4)171-175.

Gifford CA, Holland BP, Mills RL, Maxwell CL, Farney JK, Terrill SJ, Step DL, Richards CJ, Burciaga-Robles LO, Krehbiel CR (2012) Growth and development symposium: Impacts of inflammation on cattle growth and carcass merit. *J Anim Sci* 90:1438-1451.

Girodon, F., Blache, D., Monget, A.L., Lombart, M., Brunet-Lecompte, P., Arnaud, J., Richard, M.J., Galan P. (1997) Effect of two-years supplementation with low dose antioxidant vitamins and/or minerals in elderly subjects on levels of nutrients and on antioxidant defense parameters. *Journal of the American College of Nutrition* 16, 357–365.

Gunter SA, Beck PA, Phillips JK (2003) Effects of supplementary selenium source on the performance and blood measurements in beef cows and their calves. *J Anim Sci* 81:856–864.

Holland BP, Burciaga-Robles LO, VanOverbeke DL, Shook JN, Step DL, Richards CJ, Krehbiel CR (2010) Effect of bovine respiratory disease during preconditioning on subsequent feedlot performance, carcass characteristics, and beef attributes. *J Anim Sci* 2010;88:2486–2499

Institut National de la Recherche Agronomique (1988) Alimentation des bovins, ovins et caprins. INRA, Paris, France

Jim GK, Booker CW, Ribble CS, Guichon PT, Thorlakson BE (1993) A field investigation of the economic impact of respiratory disease in feedlot cattle. *Can Vet J* 34:668–1993

Juniper DT, Phipps RH, Givens DI (2008) Tolerance of ruminant animals to high dose in-feed administration of a selenium-enriched yeast. *J Anim Sci* 86:197–204.

Levander, O. (1986) Selenium. In: Trace Elements in Human and Animal Nutrition, Mertz, W. (Ed.). Academic Press, Orlando, FL, pp: 209-280.

MacPherson, A. (1994) Selenium, vitamin E and biological oxidation. In: Recent Advances in Animal Nutrition (P.C. Garnsworthy and D.J.A. Cole, eds). Nottingham University Press, Nottingham, UK.

McCord J. M. (2000): The evolution of free radicals and oxidative stress. *Am. J. Med.*, 108, 652–659.

Miller, J.K., E. Brzezinska-Slebodzinska, and F.C. Madsen. (1993) Oxidative stress, antioxidants, and animal function. *J. Dairy Sci.* 76:2812-2823.

Montgomery S.P., Sindt J.J., Greenquist M A., Miller W.F., Pike J.N., Loe E.R., Sulpizio M.J., Drouillard J.S. (2009) Plasma metabolites of receiving heifers and the relationship between apparent bovine respiratory disease, body weight gain, and carcass characteristics. *J. Anim. Sci.* vol. 87:328–333.

Nicholson JWG, McQueen RE, Bush RS (1991) Response of growing cattle to supplementation with organically bound or inorganic sources of selenium or yeast cultures. *Can J Anim* 71:803–811.

NRC (2000). Nutrient Requirements of Beef Cattle. 7th ed. NAtl. Acad. Press, Washington, DC

OIE (2010) Manual of diagnostic tests and vaccines for terrestrial animals. Cap 2.4.13, vers. adopt. May 2010, par B.2.a)

Oldfield JE (2002) Selenium world atlas. Selenium Tellurium Development Association, Grimbergen, Belgium.

Panciera R.J., Confer A.W. (2010) Pathogenesis and pathology of bovine pneumonia. *Veterinary Clinics of North America: Food Animal Practice,* 26(2):191–214

Pehrson B, Knutsson M, Gyllensward M (1989) Glutathione peroxidase activity in heifers fed diets supplemented with organic and inorganic selenium compounds. *Swed J Agric Res* 19:53–56.

Prost, M., (1992) Process for the determination by means of free radicals of the antioxidant properties of a living organism or potentially aggressive agents. In: US patent 5,135,850.

Richards C.J., Blalock H.M., Jacques K.A:, Loveday H.D. (2011) Efficacy of feeding selenium-enriched yeast to finishing beef cattle. *The Professional Animal Scientist* 27:1-8.

Rooke, J.A., Robinson, J.J., Arthur, J.R., (2004) Effects of vitamin E and selenium on the performance and immune status of ewes and lambs. *J. Agric. Sci.* 142, 253–262.

Rossi R., Pastorelli G., Corino C. (2013) Application of KRL test to assess total antioxidant activity in pigs: Sensitivity to dietary antioxidants. *Research in Veterinary Science,* 94(2):372-377.

Rotruck, J.T., A.L. Pope, H.E. Ganther, A.B. Swanson, D.G. Hafeman and W.G. Hoekstra, (1973) Selenium: Biochemical role as a component of glutathione peroxidase. *Science*, 179: 588-590.

Sgoifo Rossi C. A., Compiani R., Baldi G., Bonfanti M. (2013). Determination and assessment of BRD risk factors in newly received beef cattle. *Large Animal Review*. 19:65-72.

Sheffy, B.E., Schultz, R.D. (1979) Influence of vitamin E and selenium on immune response mechanisms. Fed. Proc. 38, 2139–2143.

Sowell BF, Branine ME, Bowman JPG, Hubbert ME, Sherwood HE, Quimby W. (1999) Feeding and watering behavior of healthy and morbid steers in a commercial feedlot. *J Anim Sci* 77:1105–1112.

Stocker, P., Lesgards, J.F., Vidal, N., Chalier, F., Prost, M. (2003) ESR study of a biological assay on whole blood: antioxidant efficiency of various vitamins. *Biochimica et Biophysica Acta* 1621, 1-8.

Swecker, W.S., Eversole, D.E., Thatcher, C.D., Blodgett, D.J., Schurig, G.G., Meldrum, J.B. (1989) Influence of supplemental selenium on humoral immune responses in weaned beef calves. *American Journal of Veterinary Research,* 50(10):1760-1763

Van Soest PJ, Robertson JB and Lewis BA (1991) Method for dietary fiber, neutral detergent fiber and nonstarch polysaccharides in relation to animal nutrition. *Journal of Dairy Science* 74, 3583–3597

Weiss, W.P. (2005) Selenium sources for dairy cattle. Page 61-71. In: Proc. Tri-State DairyNutr. Conf., Ft. Wayne, IN.

Weiss, W.P., and J.S. Hogan. (2005) Effect of selenium source on selenium status, neutrophil function, and response to intramammary endotoxin challenge of dairy cows. *J. Dairy Sci.* 88:4366-4374.

CHAPTER 6

Administration of essential oils cinnamaldehyde, eugenol, and capsicum to beef cattle: effects on health status and growth performance

Published in:
Trends in Veterinary Sciences Current Aspects in Veterinary Morphophysiology, Biochemistry, Animal Production, Food Hygiene and Clinical Sciences. Boiti et al. Ed. Springer Berlin Heidelberg. Chapter 32 , 177-180, 2013.
Abstract in: Veterinary Research Communications, Vol. 37, 251-257, 2013.

6. Administration of essential oils cinnamaldehyde, eugenol, and capsicum to beef cattle: effects on health status and growth performance

AUTHORS: R. Compiani, C.A. Sgoifo Rossi, A. Pizzi, V. Dell'Orto
**Department of Health, Animal Science, and Food Safety (VESPA), University of Milan*

6.1 Abstract

A 53-day field trial was performed to evaluate the effects of the essential oils of cinnamaldehyde, eugenol, and capsicum on the health status and growth performance of 45 Charolaise beef cattle (average arrival weight: 422.0 ± 29.3 kg; control: n = 21; treated: n = 24). Each animal was weighed, and blood samples were collected on days 0, 25, and 53. The average daily gain of the treated group was significantly higher ($P<0.05$) than that of the control. The treated group showed a significant increase in antibody for BHV-1 after vaccination ($P<0.05$ at day 25 and day 53) and significantly higher serum bactericidal activity ($P=0.01$). No differences between groups were observed for serum content of haptoglobin or reactive metabolites of oxygen. The observed improvement in growth performance and health status is due to the capacity of essential oils to optimize rumen fermentations, to increase dry matter intake, and probably to the positive interaction between essential oils and immune system components.

6.2 Introduction

Essential oils are a combination of secondary metabolites obtained from the plant volatile fraction by steam distillation (Benchaar et al. 2006). The many positive health effects of essential oils include antiseptic and anti-inflammatory properties, the ability to inactivate free radicals, and to inhibit membrane lipid peroxidation, chelate metals, and to simulate the activities of antioxidant enzymes (Trouillas et al. 2003; Lee et al. 2003). The effects of dietary administration of several essential oils to ruminants have been widely investigated in vitro (Cardozo et al. 2004, 2005; Busquet et al. 2005, 2006). Essential oils are potentially able to stimulate rumen fermentation by affecting the quantity and quality of volatile fatty acids produced and the nitrogen ruminal metabolism (Cardozo et al. 2004, 2005; Busquet et al. 2005, 2006). This study

evaluated the effects of the administration of cinnamaldehyde, eugenol, and capsicum on the growth performance and health status of fattening cattle during the adaptation phase.

6.3 Materials and Methods

A 53-day field trial was performed involving 45 male Charolaise cattle imported from France, with an average arrival weight of 422.0 ± 29.3 kg. At arrival (day 0), animals were randomly divided into two groups, control (n = 21) and treated (n = 24), and subjected to vaccination against infectious bovine rhinotracheitis virus (BHV_1), bovine viral diarrhea Type 1 virus (BVDV), parainfluenza 3 virus (PI_3), and bovine respiratory syncytial virus (BRSV).
Cattle were also subjected to antiparasitic treatment with ivermectin. A second dose of BHV_1 vaccine was administered at day 25. Both groups were fed with the same unifeed diet administered ad libitum. The diet of the treated group differed only regarding the addition of a mixture of cinnamaldehyde, eugenol, and capsicum (0.8 g/head/day). Each animal was weighed on days 0, 25, and 53 to obtain its average daily gain (ADG). On days 0, 25, and 53, blood samples were collected from 10 animals per group for the evaluation of blood parameters indicating health status, such as titration of antibodies against BHV-1 by serum neutralization test, serum bactericidal activity, haptoglobin, and reactive metabolites of oxygen (ROMs). For statistical analysis, each specific parameter at day 0 was used as a covariate.

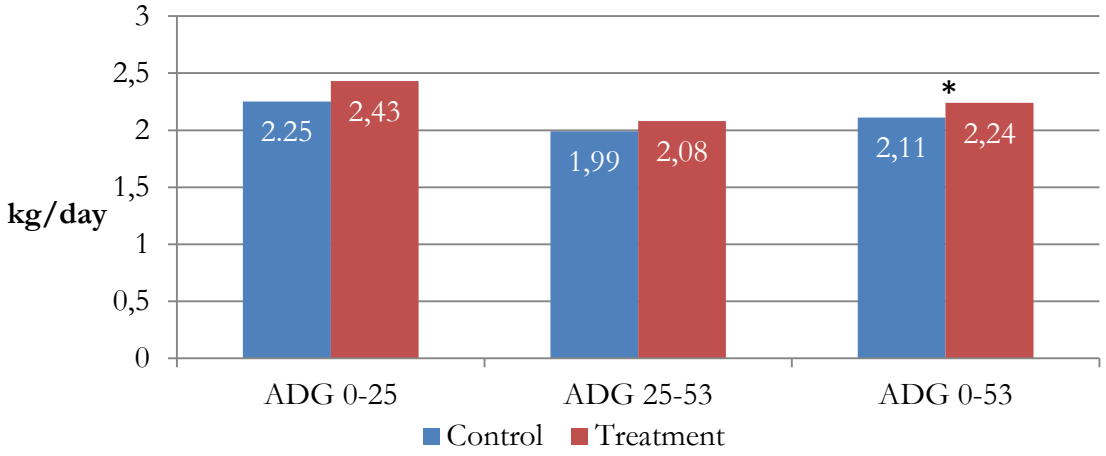
6.4 Results and Discussions

The ADG during the entire study period (d 0–53) was significantly higher ($P=0.0441$) in the treated group compared to the control group (Figure 1) and tended to be higher ($P=0.0685$) in the early period (days 0–25). Among the blood parameters used as indicators of health status, those that showed significant differences between the two groups were the serum neutralization test ($P<0.05$ at days 25 and 53) and serum bactericidal activity ($P=0.01$), with improved values in the treated group (Table 1).

Table 1. Blood parameter results.

Parameters	Day	Control	Treatment	*P*
BHV_1 serum neutralization (log_{10}(dilution))	0	0	0	-
	25	0.57	0.81	*0.04*
	53	0.90	1.02	*0.02*
Serum bactericidal activity (%)	0	87	91	-
	25	87	92	*0.01*
Haptoglobin (mg/ml)	0	0.36	0.10	-
	25	0.13	0.14	*0.79*
ROMs (mmol H_2O_2)	0	1.28	1.22	-
	25	1.54	1.44	*0.64*

Figure 1. Average daily gain of beef cattle fed a mixture of essential oils cinnamaldehyde, eugenol, and capsicum vs control (*P<0.05).



6.5 Final consideration

Growth performance was better among treated cattle as demonstrated by a significantly greater ADG of 130 g. The improved increase is probably due to the digestive process optimization induced by the treatment. The mixture of essential oils administered has been shown to improve ruminal fermentation activity and reduce methanogenesis, thereby reducing energy waste, reducing ammonia concentrations, and increasing microbial protein production as demonstrated by in vitro studies (Cardozo et al. 2004, 2005; Busquet et al. 2005, 2006). The effect of essential oils could be particularly interesting in intensive beef cattle rearing, because the antimicrobial effect is directly proportional to the

ruminal pH drop from 6.5 to 5.5 (Busquet et al. 2005, 2006; Calsamiglia et al. 2007), a range that characterizes the fattening cattle diets. Concerning the immune response, essential oil administration has helped cattle to quickly recover to physiological conditions after the stressful events typically present in newly received beef calves. Bactericidal serum activity at day 25 was higher than the threshold of 90 %, and an improvement in immune response to vaccination was also observed. These positive effects can be attributed both to the rumen fermentation optimization and to the increase of dry matter intake (Yang et al. 2010a, b), but also to a direct effect of the essential oils with immune system cells. This second mechanism needs to be investigated further. The use of essential oils of cinnamaldehyde, eugenol, and capsicum in newly received beef cattle diet seems to be a successful strategy to improve growth performance and immune response during the adaptation phase.

6.6 References

Benchaar C, Petit HV, Berthiaume R, Whyte TD, Chouinard PY (2006) Effects of addition of essential oils and monensin premix on digestion, ruminal fermentation, milk production, and milk composition in dairy cows. *J Dairy Sci* 89:4352–4364

Busquet M, Calsamiglia S, Ferret A, Kamel C (2005) Screening for the effects of natural plant extracts and secondary plant metabolites on rumen microbial fermentation in continuous culture. *Anim Feed Sci Technol* 123(124):597–613

Busquet M, Calsamiglia S, Ferret A, Kamel C (2006) Plant extracts affect in vitro rumen microbial fermentation. *J Dairy Sci* 89:761–771

Calsamiglia S, Busquet M, Cardozo PW, Castillejos L, Ferret A (2007) Invited review: essential oils as modifiers of rumen microbial fermentation. *J Dairy Sci* 90:2580–2595

Cardozo PW, Calsamiglia S, Ferret A, Kamel C (2004) Effects of natural plant extracts on protein degradation and fermentation profiles in continuous culture. *J Anim Sci* 82:3230–3236

Cardozo PW, Calsamiglia S, Ferret A, Kamel C (2005) Screening for the effects of natural plant extracts at different pH on in vitro rumen microbial fermentation of a high-concentrate diet for beef cattle. *J Anim Sci* 83:2572–2579

Lee SE, Hwang HJ, Ha JS, Jeong HS, Kim JH (2003) Screening of medicinal plant extracts for antioxidant activity. *Life Sci* 73:167–179

Trouillas P, Calliste CA, Allais DP, Simon A, Marfak A, Delage C, Duroux JL (2003) Antioxidant, anti-inflammatory and antiproliferative properties of sixteen water plant extracts used in the Limousin countryside as herbal teas. *Food Chem* 80:399–407

Yang WZ, Ametaj BN, Benchaar C, Beauchemin KA (2010b) Response to cinnamaldehyde supplementation in growing beef heifers: ruminal and intestinal digestion. *J Anim Sci* 88:680–688

Yang WZ, Ametaj BN, Benchaar C, He ML, Beauchemin KA (2010a) Cinnamaldehyde in feedlot cattle diets: intake, growth performance, carcass characteristics, and blood metabolites. *J Anim Sci* 88:1082–1092

CHAPTER 5

General Discussion

7. General discussion

Preventive strategies could help strongly in reducing morbidity in intensive beef cattle rearing. A rational approach to risk management, a better knowledge of diseases' etiopathogenesis, and the adoption of feed additives to improve rumen activity and immunity are strategies able to satisfy several objectives.

First of all, reducing the possibility of animals to fall into diseases have an ethical meaning considering that the third of the five freedoms at the base of the animal welfare is to let them free from pain, injury or disease by prevention or rapid diagnosis and treatment. Animal welfare is becoming day by day a key aspect in livestock production for two reasons. Keep animals in a good welfare condition during their life in farm is not only an ethical issue but has also economic repercussions. A sick animal lead to the increase of production cost because of treatments, increasing in working time, elongation of rearing time with increasing of fixed costs and reduction of growing performances. Furthermore, the probability of death in case of illness increases. This aspect and the relative costs of amortization and carcass destruction or depreciation, should be considered carefully in a good farm economic balance. Of course, the economic impact of morbidity is strictly related to each specific disease, but in any case a different level of growth reduction happens because the reduction of feed intake due to fever and pain. To reach the correct carcass characteristics asked by slaughterhouse, the rearing period becomes generally longer, overstepping very often the period in which cattle have the best growing ability, thanks to a very efficient feed to conversion rate. This is the reason why carcass traits of animals even recovered from illness, are often poor with a reduction of their value. This finding, is probably not only a matter of feed efficiency, since some authors are identifying specific growth factors and inflammatory mediators able to interfere with proper muscle tissue development after illness.

Furthermore, welfare acquires another positive economic meaning considering the increasing importance that consumers are giving to this aspect. Efforts made to improve farm environment and management will probably be rewarded very soon thanks to rising marketing projects based on animal food product produced with high welfare standards.

Is necessary to keep in mind that welfare and animal health are not only a matter of profitability and ethics, but are even requirements asked by law regulations.

The law regulation aims to protect human safety. The more recent purpose of European Governance is to avoid the risk of rising of microbes antibiotic resistance and asks for the reduction of antibiotics administration in livestock. This can be achieved only thanks to good preventive strategies.
The two main diseases that need to be treated with drugs in beef cattle rearing are respiratory disease and lameness. These two main health problems are impossible to avoid completely since the rearing condition are not fully suitable to young cattle. But their incidence can be reduced a lot thanks to a better knowledge and the management of their risk factors. The identification of the multiple risk factors and the quantification of their negative effects allow to the evaluation of suitable and well-considered health interventions with respect to the risk connected to the newly arrived animals.
The system developed to assess BRD risk for each group of young cattle arriving to fattening unit, is not an all-encompassing theorem that can completely solve the problem of BRD in beef cattle rearing, but can instead be used as a dynamic instrument available to veterinarians in order to limit the negative impacts of the disease and as a referral technique for the farmer, who can precisely quantify the economic impact of every single risk factor. The objective was indeed to provide a tool able to help in planning to decrease the uncertainty when making investment decisions about necessary interventions and other realities of farming.
Regarding lameness, the better knowledge of the possible pathologies at the base of this abnormal behavior is very important, among other things, to achieve the target of the prudent and correct use of drugs in veterinary medicine, since antibiotics treatment is not useful in every situations. A lack in the management of this health problem in intensive beef system is related to infrequent detection of lameness diagnosis and severity. Even in case of great lameness morbidity, seldom in field conditions the real cause is clearly identified and often occur diagnostic misinterpretations based only on visual inspection. With correct handling and containing facilities can be made a proper clinical examination of the affected limb. Furthermore, the use of additional diagnostic procedures and tools can help and speed up the decision-making process not only about the fate of a specific lame animal but also to identify the cause behind of a widespread problem in the herd. In this way, can be adopted specific preventing strategies in order to limit drugs administration, not essential in every case of lameness.

In the actual rearing condition, stressful events can be reduced while animals are in the fattening units but is very difficult to completely avoid them since they are also related to transport stressor circumstances. The use of specific feeding strategies as organic selenium supplementation or essential oil during the adaptation phase have proved to be effective in reducing health problems. In the trial performed about the administration of selenium from organic source instead from inorganic one, BRD morbidity was reduced with a relative better growth performance. The high selenium bio-availability from organic source led to a better recover after transport event and improved antibody response after vaccination. Even, the administration of the mixture of essential oils of cinnamaldehyde, eugenol, and capsicum, led to a quickly recover from transport stress and to a better immune reaction after vaccination. In this situation, these positive findings can be attributed both to the rumen fermentation optimization and to the increase of dry matter intake. Further investigation are needed to evaluate the possibility of a direct effect of essential oils on immune system cells, as reported in *in vitro* studies.

The aim to optimize the productive performance of beef cattle reducing health related inefficiencies has thus only several positive repercussions. In some circumstances could seem to be expansive in economic and effort terms but, in the end, leads only to a better return. Develop risk management protocols, apply them and analyze the results that come out, is at the base of the planning of preventive strategies. Prevention should be seen as an opportunity to improve and lift up the beef sector managing any aspect of it as happens in any other economic sector.

CHAPTER 6

Summary

8. Summary

The strategies to optimize the meat production process are mainly aimed at maximizing growth performance, reducing in this way the days on feed needed to achieve the slaughtering time. These strategies can be grouped into three categories: develop a proper diet to the needs of different types of animals in the different stages of production as well as the objectives of the farmer, improve the farm environment and therefore animal welfare, improve animal health.
This PhD dissertation discussed and evaluated strategies to optimize the productive performance of beef cattle improving animal health condition, reducing morbidity and assess the risk to plan preventive approaches.

8.1 Work 1

Respiratory Disease (BRD) is the main health problem in intensive beef cattle rearing. BRD is a multifactorial syndrome, and its etiopathogenesis is influenced by several predisposing and triggering factors. Management of the numerous risk factors is essential to maintaining appropriate preventative and therapeutic practices in the rearing of feedlot cattle. Because of the many stresses and the inevitable exposure to pathogens, incidences of BRD may be limited, but not avoided entirely. We propose a system for evaluating the potential risk of BRD for each new delivery of feedlot cattle, using a point attribution system that scores the principal risk factors of the production system, which is in turn able to judge the susceptibility of the animals to respiratory disease. The comprehensive risk assessment begins with an assessment of subject inherent risk in relation to weight, sex, race, transport length, transportation shrink, and the management practices of the breeding farm, which can be exacerbated or reduced by the management practices and structures present at the fattening facility. The analysis of risk allows for the focused management of each newly received lot of cattle in relation to its probable incidence and severity of BRD, providing the basic conditions for effective prevention and management of respiratory disease in the rearing of fattening cattle. Analysis of the data generated by the risk assessment system allows the quantification of the impact of each risk factor on the farm balance sheet, highlighting the cost-effectiveness of changes to management practices and investments in structural equipment.

8.2 Work 2

Lameness is one of the main health and economic issues concerning not only dairy but even beef cattle production system. Lameness is a clinical condition in case of locomotor apparatus diseases (LAD) and is characterized by multiple triggering (microbial, mechanical, nutritional, and genetic) and predisposing factors (subjective and environmental). The aim of this work was to review the lameness causes and risk factors of beef cattle reared in the intensive system and in particular in the Italian situation. The results of the surveys proposed, show that in Italian intensive beef cattle rearing, LAD is an important problem characterized by variable incidence and different risk factors. Heavy Charolaise bullocks are more predisposed to LAD. Floor is one of the main risk factor, but the right choice of which animal will be housed on slatted floor can strongly limit arthropathies incidence and a proper litter management can prevent foot diseases. Other livestock facilities and management can limit or promote LAD incidence and severity. Furthermore even feed quality control, a proper vitamins and minerals integration and the gradual transition from arrival to finishing diet, limit acidosis events and then laminitis. The right diagnosis and the knowledge of the main features related to LAD can help and speed up the decision-making process not only about the fate of a specific lame animal but also to identify the cause behind of a widespread problem in the herd. In this way, can be adopted specific preventing strategies in order to limit drugs administration, not essential in every case of lameness.

8.3 Work 3

The effects on health and growth performance of two different sources of selenium administered to newly received beef cattle were evaluated in a 54 days field trial. 228 Limousine x Charolaise crossbreed bullocks (average age: 13 ± 1 months; live weight: 374.84 ± 29.43 kg) imported from France to an Italian fattening unit were enrolled in the study and monitored for the entire adaptation phase. At arrival, animals were vaccinated, treated for internal and external parasites and received a preventive antibiotic mass treatment because considered at high risk to develop respiratory diseases. Animals were housed on concrete floor covered by straw litter and provided ad libitum access to water, hay for the first 5 days and a specific adaptation diet formulated to meet or exceed nutritional requirements. Experimental groups diets were different only with

regard to mineral and vitamin mix that were formulated with the aim to provide 3 mg of selenium per day from different sources (Control: sodium selenite (NaSe); Treatment: selenised yeast (Se-Y)). At experimental days 0, 19 and 54, animals were weighted individually to evaluate ADG, and blood samples were collected to evaluate serum selenium content, neutralizing antibody levels, serum bactericidal activity and total antiradical activity of whole blood and red blood cells. Treatment positively affected serum selenium content proving that organic sources of this trace mineral are characterized by higher bio-availability. Se-Y supplemented bullocks have greater ADG as a consequence of a lower incidence of respiratory diseases (BRD). BRD affected animals in Se-Y sub-group had a better recover after illness period since their ADG was higher than in Na-Sa supplemented sick animals. The higher level of circulating selenium since the first days after arrival have led Se-Y bullocks to a better recover after transport stress. Se-Y group has a better immune-reaction after exposure to the vaccinal antigen and higher blood total antiradical activity. In the present experimental condition, the supplementation of 3 mg of selenium from organic source respect inorganic one, led to the improvement of immunity and antioxidant ability of newly received beef cattle. The higher bio-availability of selenised yeast is likely able to help animals to better and quickly recover after transport stress and illness events. The improvement of immunity and antioxidant ability reduced BRD morbidity promoting better growing performance.

8.4 Work 4

A 53-day field trial was performed to evaluate the effects of the essential oils of cinnamaldehyde, eugenol, and capsicum on the health status and growth performance of 45 Charolaise beef cattle (average arrival weight: 422.0 ± 29.3 kg; control: n = 21; treated: n = 24). Each animal was weighed, and blood samples were collected on days 0, 25, and 53. The average daily gain of the treated group was significantly higher ($P<0.05$) than that of the control. The treated group showed a significant increase in antibody for BHV-1 after vaccination ($P<0.05$ at day 25 and day 53) and significantly higher serum bactericidal activity ($P=0.01$). No differences between groups were observed for serum content of haptoglobin or reactive metabolites of oxygen. The observed improvement in growth performance and health status is due to the capacity of essential oils to optimize

rumen fermentations, to increase dry matter intake, and probably to the positive interaction between essential oils and immune system components.

CHAPTER 7

Acknowledgements

9. Acknowledgements

Three years of hard work, three years passed in a while, three years full of joys, three years with few but terrible sad moments, three years of professional and personal growth, three years of satisfactions, three years full of shit, three years of friendship, three years of drinks, three years of emergencies handled at its best, three wonderful years…

A special thanks to Carlo, a leader, a partner, a great friend. Always present with his heart, his spirit, his soul, his positive view of life, his strength and his enthralling enthusiasm. In the lasts years we have shared so much, almost everything, for better and for worse. To you I owe so much, perhaps even everything and not only from a professional point of view but also from a human. How many beautiful things are waiting for us in the future. What the fuck, it seems that I'm writing a love letter to a special girl, but that it is.
Thank you Carlo, I love you.

I want to thank my tutor, Prof Vittorio Dell'Orto that gave me the possibility to achieve this result and to enter in this wonderful world.
A heartfelt thanks to some special friends and colleagues that I luckily fall on them during this last years, always available for advice and help and giving to me opportunities, trust and responsibility. With the hope and the commitment not to have ever disappointed and never disappoint you in the future. Thank you very much: Claudio Santambrogio, Stefano Vandoni, Matteo Biancardi, Michele Vandone, Michele Muraro, Giovanni Galmozzi, Maurizio Bonfanti, Andrea Zanovello, Giuseppe Ripamonti, Gianluca Baldi.

I'd like to give a thankful hug to all of my real friends, always present in the time of need. I'm very lucky because you are many and terrific. Thank you very much: Nicola Morandi, Claudio Guglielmi, Marco Signorelli, Carlo Giudici, Francesco Aulisio, Riccardo Fumagalli, Alberto Tosi, Michele Arioli, Simone Vignati, Antonio Boccardo. Someone said "Friends are the family you can choose" but I have to thank even the one I did not choose. Very lucky to have a little messed up family, thank you Mom and Dad.

In the end of these acknowledgements, I'm realizing to be a very lucky guy, but I think luck is not enough in life and seems to be right to thank even… myself, since without conceit, I work hard, I do not give up and I respect who deserve it and even those who do not. I'm sure to deserve who I am and what I have, and probably even something more.

I am ready for the new season on changes even if I've never thought I would have uses it again:

The carousel is spinning fast
better enjoy while it lasts.
Every moment is like gold
you'll remember when you're old.
And the meaning of this life
is to live and is to die.
Make the best out of your dreams
they're the world where you are free.
All the sorrow and the pain
will be washed away by rain.
An eternal joy will come
it can be found by everyone.
Though the end is drawing near
I'm not feeling any fear.
I have found the truth inside
after all the tears I've cried.

Season of Change...(Stratovarius, 1996)