Italian Journal of Animal Science

ISSN: (Print) 1828-051X (Online) Journal homepage: http://www.tandfonline.com/loi/tjas20

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To cite this article: Adele Meluzzi & Federico Sirri (2009) Welfare of broiler chickens, Italian Journal of Animal Science, 8:sup1, 161-173, DOI: 10.4081/ijas.2009.s1.161

To link to this article: http://dx.doi.org/10.4081/ijas.2009.s1.161

REVIEW ARTICLE

Welfare of broiler chickens

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Paper received January 22, 2008; accepted March 20, 2008

ABSTRACT

Broiler chickens have been selected for their rapid growth rate as well as for high carcass yields, with particular regard to the breast, and reared in intensive systems at high stocking density ranging from 30 to 40 kg live weight/m^2. These conditions lead to a worsening of the welfare status of birds. In Europe a specific directive for the protection of broiler chickens has been recently approved whereas in Italy there is not yet any regulation. The EU directive lays down minimum rules for the protection of chickens kept for meat production and gives indications on management practices with particular focus on stocking density, light regimen and air quality, training and guidance for people dealing with chickens, as well as monitoring plans for holding and slaughterhouse.

In this review the rearing factors influencing the welfare conditions of birds are described and detailed information on the effects of stocking density, light regimen, litter characteristic and air quality (ammonia, carbon dioxide, humidity, dust) are provided. Moreover, the main health implications of poor welfare conditions of the birds, such as contact dermatitis, metabolic, skeletal and muscular disorders are considered. The behavioural repertoire, including scratching, dust bathing, ground pecking, wing flapping, locomotor activity, along with factors that might impair these aspects, are discussed. Lastly, farm animal welfare assessment through physiological and behavioural indicators is described with particular emphasis on the "Unitary Welfare Index," a tool that considers a wide range of indicators, including productive traits, in order to audit and compare the welfare status of chickens kept in different farms.

Key words: *Gallus gallus*, Broiler chicken, Welfare, Behaviour.

RIASSUNTO

IL BENESSERE DEL POLLO DA CARNE

I polli da carne sono stati selezionati per una rapido accrescimento ed una elevata resa in carne, in particolare del petto, e sono allevati con sistema intensivo a densità elevate, da 30 a 40 kg di peso vivo per m^2. La massimizzazione degli indici produttivi ha portato tuttavia ad un peggioramento delle condizioni di benessere dell'animale. In ambito europeo è stata approvata una direttiva per la tutela del pollo mentre in Italia non esistono ancora disposizioni legislative a tal riguardo. La direttiva dell'UE stabilisce le norme minime per la protezione del pollo allevato per la produzione di carne e fornisce indicazioni riguardo la gestione dell'allevamento, con particolare riferimento a densità, fotoperiodo e qualità dell'aria, la formazione del personale

addetto ed i piani di monitoraggio e controllo da eseguire in allevamento ed al macello.
In questa rassegna vengono presi in esame i fattori di allevamento che interferiscono sulle condizioni di benessere degli animali e considerati in maniera dettagliata gli effetti della densità di allevamento, del fotoperiodo, della intensità della luce, delle caratteristiche della lettiera e della qualità dell'aria (ammoniaca, anidride carbonica, umidità, polveri). Sono descritte le principali alterazioni dello stato di salute degli animali come le dermatiti da contatto, i disordini metabolici, dell'apparato scheletrico e muscolare provocati da inadeguate condizioni di benessere. Sono trattati il repertorio comportamentale dell'animale comprendente il razzolamento, il bagno di sabbia, il becchettare, lo sbattimento delle ali, le attività motorie ed i fattori che lo condizionano. Infine si forniscono indicazioni sui sistemi di valutazione del benessere che può essere effettuata attraverso indicatori fisiologici e comportamentali oppure attraverso l'"Unitary Welfare Index", un indice che riassume le misure di numerosi indicatori di benessere, compresi quelli produttivi, e che consente di confrontare lo stato di benessere di animali di diverse aziende.

Parole chiave: Gallus gallus*, Pollo da carne, Benessere, Comportamento.*

Introduction

Broiler chickens have been submitted to an intensive genetic selection that has been increasing the growing rate and made them the fastest growing farmed species. The production is obtained mostly in intensive systems by using uniform and standardised tools and techniques as for genotype, feeding, housing and management. Birds are reared on floors covered with litter that is removed at the end of each cycle before carrying out cleaning and disinfection procedures. Birds have free access throughout their life to feed and water which are automatically distributed. The broilers are separately reared according to the sex in different poultry houses or in the same shed but in different areas. The cycle lasts from 40 to 60 days depending on the sex and carcass size requested by the market. Indeed, birds can be slaughtered at live weights ranging from 1.7 to 3.5 kg and the stocking density in the housing is directly related to the target weight at slaughtering, but also to the occurrence of depopulation procedures. According to the bird live weight at slaughtering, the stocking density ranges from 25 to 40 kg/m^2. The majority of the broiler chicken production is obtained in intensive systems and only a small niche is represented by chickens reared in alternative and organic systems according to the Regulations Commission 1538/91 and 1804/99, respectively (European Commission, 1991, 1999). The former gives indications of 5 different types of production that differ from the conventional intensive system for the feeding (with the indication of the percentage of some particular ingredients such as "Fed with….% of …..") or for the space allowances given to the birds. In these cases the stocking densities per m^2 of floor space must not exceed 27.5 kg live weight per m^2 for "Free range", 25 kg live weight per m^2 for "Extensive indoor" and "Traditional free range," whereas no limitation of space allowances are given for "Free range – total freedom". Moreover, with the free range systems, birds are kept in small groups and they have access to open air runs with the availability of outdoor space of 1-2 m^2 up to an unlimited area per bird. In the organic system birds are kept in conditions very similar to those of the "Traditional free range" with the exception of feeding (organic feed) and health care.

Legislative regulations on broiler protection

In Italy there are no legislative regulations regarding the intensive broiler rear-

ing system and in Europe only Sweden and Switzerland have rules that regulate chicken production. In other countries (Germany and UK), official recommendations for broiler production have been developed while in most EU countries only the recommendations of breeding companies are followed. With increasing consumer concern for the welfare of reared animals and for the quality of the food, the need for assessing welfare conditions of chickens raised for commercial purposes has become increasingly evident. In regard to this issue, the Scientific Committee on Animal Health and Animal Welfare of the European Commission (SCAHAW, 2000) has published a report on the status of the rearing conditions of broilers with particular focus on the factors linked to animal welfare. In 2005 a first draft of a proposal for a Directive "Laying down minimum rules for the protection of chickens kept for meat production" (European Commission, 2005) was prepared and submitted to several changes and implementations. This draft aims "to introduce animal welfare improvements in the intensive farming of chickens by means of technical and management requirements for the establishments, including enhanced monitoring on the farms and an increased flow of information between the producer, competent authorities and the slaughterhouse based on a welfare monitoring program of the chicken carcasses after slaughter".

An important parameter taken into account by the European Commission in the proposal is the stocking density of chickens kept on farms which should not at any time exceed 32 kg live weight per m^2; the average of the maximum stocking density of the last 3 crops should not be greater than 30 kg per m^2 to ensure good welfare conditions for the chickens. As for lighting, all buildings shall have light with an intensity of at least 20 lux during the light periods measured at the bird eye and illuminating the whole of the floor area; the light must follow a 24-hour rhythm and include periods of darkness lasting at least 8 hours in total with the exception of the first and last 3 days of life. Moreover, other specifications regarding drinking, feeding and litter management as well as ventilation, heating, cleaning and inspection procedures are mentioned. The competent Authority may provide that chickens be kept at a maximum stocking density which does not at any time exceed 40 kg per m^2 and ensure that the average of the maximum stocking density of the last 3 crops not be greater than 38 kg per m^2 provided that the owner complies with several requirements. The main needs are the following: CO_2 and NH_3 should not exceed 3,000 ppm and 20 ppm, respectively, at the level of chicken heads; the inside temperature, when the outside temperature exceeds 30°C, should not exceed the outside temperature by more than 3°C; the inside relative humidity, when the outside temperature is below 10°C, should not exceed 70%. Moreover low mortality rate, low foot pad score, and frequent inspections of the poultry house are requested; in particular mortality rate must be lower than 1%+0.06% multiplied by the slaughter age of the flock in days. The foot pad dermatitis score should not exceed 50 points calculated on a sample 200 feet per flock. The foot score is established according to the following procedure: 0=no lesions, 1=mild lesions and 2=severe lesions. The number of feet from group scored 0 is not taken into account. The number of feet from group scored 1 is multiplied by 0.5, the number of feet from group scored 2 by 2. Both results are added, then the total is divided by the sample size and multiplied by 100. On the 28th of June 2007, the Council of the European Union approved Directive 2007/43 EC. From the original draft, the maximum density was

fixed at 33 kg live weight/m^2, instead of 32, with the possibility to increase the limit to 39 and 42 kg live weight/m^2, instead of 38, if some of the above-mentioned requirements are fulfilled. The period of darkness was reduced to 6 h a day instead of 8 h. As for the foot pad dermatitis score, even if it is considered from a scientific point of view a good indicator of broiler welfare, it was elicited from the Directive. Member states shall bring into force the laws, regulations and administrative provisions necessary to comply with the Directive by 30 June 2010 at the latest (European Commission, 2007).

Main welfare issues of broiler farming

Rearing system

Several factors may affect bird welfare: these include the rearing system (equipment and facilities, stocking density, light regimen and intensity, litter and air quality, gases, air contaminants and humidity, temperature), nutrition and feed management, catching, handling and transport. The most important of these subjects are discussed below.

Stocking density

Stocking density in broiler houses is usually expressed either as the number of housed birds or as the live weight (kg) per m^2 floor space at depopulation or at the end of growing period.

In intensive poultry production, broiler chickens are reared at high stocking density since it is assumed that by increasing the density the income of the production increases; however, it is also known that the increase of the density reduces the bird welfare. Several studies have been carried out on broiler stocking density ranging from 10 to 50 kg/m^2 floor space (Shanawany, 1988; Grashorn and Kutritz, 1991; Meluzzi *et al.*, 2003, 2004). It is well documented that with stocking density over 30 kg/m^2 floor space growth rate is reduced as a result of the heat stress (McLean *et al.*, 2001). Indeed, with crowded birds the dissipation of metabolic heat increases along with the increase of the litter temperature in relation to the higher content of moisture and nitrogen, which enhances the microbial activity. With increasing stocking densities the temperature raised to more than 30°C beneath and on the surface of the litter, while a normal temperature (about 22°C) was recorded from 20 cm to 100 cm above the litter regardless of the stocking rate (Reiter and Bessei, 2000). It has been demonstrated that the ventilation rate can play a key role in alleviating the negative effect of stocking density (Grashorn and Kutritz, 1991). In intensive commercial production the use of ventilation along with the adoption of curtains to increase the air speed has spread due to the beneficial effects on bird welfare in relation to the heat dissipation. The effect of stocking density on feed conversion rate is controversial since some authors found that this trait improved or worsened at high stocking densities whereas others did not observe any effect (Shanawany, 1988; Bessei, 1993; Meluzzi *et al.*, 2008). Shanawany (1988) reported an increased mortality rate as stocking density increased. In a field trial carried out on 270,000 broiler chickens, Meluzzi *et al.* (2007) did not find any relationship between mortality and stocking rate thereby confirming previous findings of Cravener *et al*. (1992).

Stocking density can also affect some behavioural activities of birds such as locomotor activity, preening, scratching and resting but the experimental results are conflicting. Ferrante *et al.* (2006), comparing a stocking density of 28 and 35 kg/m^2, found a greater latency (72.3 *vs* 67.1) but no significant difference regarding the tonic immobility. In general, walking ability and the access to feeders and drinkers can be reduced when

very low and very high stocking densities are compared. Indeed, both Blokhuis and Van der Haar (1990) and Lewis and Hurnik (1990) found similar results working with densities ranging from 2 to 20 birds/m^2 and from 7.5 to 15 birds/m^2, respectively. In other experiments Bessei (2004) did not find any significant differences in locomotor and other behavioural activities in broilers reared in large groups and stocking rates from 10 to 25 birds per m^2. Moreover, with a stocking density increase greater than 10 birds/m^2, locomotor activity and scratching behaviour decreased but no changes occurred within the usual commercial stocking rates (Bessei, 1993). Under commercial conditions, there is a sharp decline in most behavioural activities within the first week of life while at the end of the growing period, when physical space is at a minimum, the effects of stocking densities on behavioural traits are small. Dawkins *et al.* (2004) in a large field survey concluded that housing conditions (litter quality, temperature and humidity) were more important than stocking density itself.

Light regimen and intensity

In commercial conditions broilers are reared in near continuous light in order to maximise feed intake and daily weight gain and are usually provided with a short dark period of 1 h each day to allow them to become accustomed to darkness in the event of a power failure. However, there is some evidence that the adoption of a short day length in the early stage of growth may reduce the incidence of skeletal and metabolic disorders, mortality and downgrades (Zubair and Leeson, 1996). Broilers may also benefit from a clear pattern of day and light by having a distinct period of rest and more vigorous periods of activity, which has a positive effect on bone mineralisation. Ferrante *et al.* (2006) claimed that birds reared with a more natural photoperiod showed a prevalence of activity in the feeding through area mainly in early morning and late afternoon. In experimental conditions Meluzzi *et al.* (2007) observed that a short photoperiod (16 h light and 8 h dark) did not affect broiler growth while feed intake and feed efficiency were respectively lower and better than those of birds kept with a conventional, long photoperiod. The results concerning feed intake and efficiency were confirmed also in field trials where the effects of combined short photoperiod along with low stocking density were studied (Meluzzi *et al.*, 2003). Therefore, the adoption of photoperiods similar to the natural one occurring in summer season in temperate zones assures better living conditions to the birds without detrimental effects on production provided that the feeder space per bird is adequate.

Light intensity wavelength and source of light can influence the activity of broilers. High light intensity increased the locomotor activity and reduced leg problems in six-week-old broilers (Newberry *et al.*, 1988). Despite higher locomotor activity at high light intensity there was no negative effect on growth rate and feed conversion. Since bright lighting increases the risk of outbreaks of injuries and very low light intensity (< 5 lux) can cause eye abnormalities (Jenkins *et al.*, 1979) from a welfare point of view a light intensity of 20 lux is recommended.

Litter and air quality

Litter quality is of great importance for the welfare of broiler chickens as they generally spend their entire life in contact with it. Litter quality will affect the environmental situation of the birds by influencing dust levels, air humidity and ammonia levels, which, in turn, lead to respiratory problems. It also has a direct influence on the skin condition of the birds, wet litter being

a major risk factor for contact dermatitis (SCAHAW, 2000). Many authors have found positive correlations between litter quality, particularly moisture, and incidence of foot pad dermatitis (Harms *et al.*, 1977; Algers and Svedberg, 1989; Ekstrand *et al.*, 1997). Meluzzi *et al.* (2004) found that a lower litter pH caused by a high stocking density enhanced the incidence of foot pad dermatitis. When stocking density is increased, litter quality worsens leading to an increased incidence of foot pad dermatitis, but this relationship may be as evident when the increased stocking density is compensated by improvements in management factors such as ventilation capacity (Berg, 1998). Litter materials with a high water-holding capacity, such as wood shaving, are believed to result in better litter quality than litter materials with poorer absorption capacity such as straw (SCAHAW, 2000). Meluzzi *et al.* (2007) raised birds on chopped straw or wood shavings both in winter and in summer seasons and observed that birds kept on wood shavings exhibited a reduction of 35% in foot pad dermatitis than those kept on straw. Other bedding materials, such as peat moss or sawdust, have a high water holding capacity but result in a dusty environment (Shanawany, 1992). Litter layers lower than 5 cm result in lower levels of foot pad dermatitis than thicker layers since the birds are more prone to peck, scratch and turn the litter particles over thus ventilating and drying the litter. Moreover a thin litter layer may also be thoroughly ventilated by airstreams from the fans (Ekstrand *et al.*, 1997).

Air quality is a composite variable of air constituents such as gases (mainly ammonia, carbon dioxide and oxide), dust and micro-organisms which are widely considered to be principle risk factors for respiratory diseases. Temperature and humidity influence the thermal comfort of the birds (SCAHAW, 2000). If environmental relative humidity is lower than 50% there is a higher production of dust and an increase in the number of air borne micro-organisms which might increase susceptibility to respiratory diseases, but this situation is not very common. High relative humidity up to 80% can occasionally be reached with high stocking densities in winter when the ventilation rate is normally reduced due to economic reasons. Also, during summer birds often experienced conditions of discomfort mainly due to the combined effect of high humidity (deriving both from outside air and the cooling system) combined with high temperature. Ammonia is an abundant pollutant in broiler houses and it may have a great impact on poultry welfare (Kristensen and Wathes, 2000). Ammonia is formed during the decomposition of uric acid and the efficiency of this conversion is directly related to the level of litter moisture. High levels of ammonia are responsible for the onset of respiratory diseases and keratoconjunctivitis. Dust in broiler houses arises from small pieces of feathers, skin scales, litter and dried manure and can be divided in 2 fractions: inspirable (particles larger than 5 µm) and respirable fractions (particles smaller than 5 µm). It plays an important role in the transmission of many infections and it can cause a direct inflammation of bronchi, particularly in combination with ammonia, low humidity and high temperatures (Kristensen and Wathes, 2000).

Air quality should be controlled and maintained within the limits that are not harmful for animal welfare. In fact the Directive (European Commission, 2007) advises 20 ppm for ammonia, 3,000 ppm for carbon dioxide and 70% for humidity as upper limits.

Nutrition and feed management

The general objective of nutrition is to

maximise the economic production performance of broilers but good nutrition is also important from a health point of view. Nowadays a clear nutrient deficiency is rare but an adequate feeding regimen can improve health and welfare in birds under stressful conditions. In particular, in case of heat stress, decreasing the crude protein content of the diet and supplementing it with an adequate level of essential amino acids will help the birds to reduce the metabolic heat production during digestion. Also, the use of high concentrations of ascorbic acid can help the birds to alleviate heat stress while the supplementation of high amounts of vitamin A and E can be effective in enhancing the activity of the immune system (Manfreda *et al.*, 1994). Among vitamins, the dietary supplementation of vitamin D and its metabolites, particularly 25-hydroxycholecalciferol, is an effective nutritional tool to prevent the onset of skeletal disorders such as tibial dyschondroplasia and osteoporosis (Rennie and Whitehead, 1996). Nutrition can also indirectly impact bird welfare by acting on the environment. Indeed the use of an excess of sodium salt in the diet can enhance the water content of droppings leading to poor litter conditions. Moreover, the use of very high levels of inclusion of raw materials rich in non starch polysaccharides, which are indigestible for the birds, may raise the moisture content of litter, as can an excessive concentration of crude protein, which may thus enhance the nitrogen content of the litter and lead to serious consequences on foot pad lesions.

Health and disease

Contact dermatitis

Contact dermatitis is a relatively widespread problem in European broiler production. In severe cases dermatitis may cause pain which, together with a deteriorated state of health, constitutes a welfare issue. Apart from the animal welfare aspect, contact dermatitis is relevant to the poultry meat industry since broilers with severe foot pad lesions have slower weight gain as a result of pain-induced inappetance (Ekstrand and Algers, 1997). Indeed birds affected by foot dermatitis are reluctant to move and have serious problems in reaching feeding troughs and drinkers. Moreover, in the presence of high incidence of food pad dermatitis, other downgrading factors such as breast blisters and hock burns can also occur thus reducing the profitability. Hock burns, breast blisters and foot pad lesions may be summarised under the expression "contact dermatitis". They are characterised by hyperkeratosis and necrosis of the epidermis of the affected sites. In an advanced stadium there are inflammations of the sub cutis with degeneration of tissues. Secondary infections may further worsen the conditions of the birds. There is evidence that the contact dermatitis causes pain and thus is a matter of welfare (Bessei, 2006). Several risk factors are responsible for the onset of foot dermatitis including type, depth and condition of litter, stocking density, feed composition, light and climate. Broilers spend their life in contact with litter and also in contact with droppings which form part of the litter surface; therefore, if the litter conditions are not optimal there is a considerable risk that birds will develop contact dermatitis, hocks and breast blisters. Food pad status is a better sensitive indicator of litter problems than hock or breast status (Berg, 2004). The water holding capacity of litter is a fundamental factor in preserving the foot in a good state. A lower incidence of foot pad dermatitis has been observed in birds kept on wood shavings in comparison with chopped straw (Meluzzi *et al.*, 2007). Foot pad dermatitis has been found to be more common in flocks reared

on a thick layer of litter material than in flocks on thin layers (Ekstrand *et al.*, 1997). The incidence of lesions is strictly related to the litter moisture. The higher the latter is, the higher the incidence of contact lesions (Ekstrand *et al.*, 1997; Meluzzi *et al.*, 2008). Stocking density has been reported to influence litter quality. Reduced litter quality at high stocking density leads to an increased incidence of contact dermatitis (Proudfoot *et al.*, 1979; Blokhuis and Van der Haar, 1990) particularly in the winter season (Meluzzi *et al.*, 2008). Epidemiological studies have shown a significant association between foot pad dermatitis and feed manufacturer and, in turn, diet composition (Ekstrand and Carpenter, 1998b; Ekstrand *et al.*, 1998). Indeed the high content of salt in the diets as well as the use of raw materials rich in non starch polysaccharides (wheat, barley and oat) can result in wet litter which may, in turn, increase the prevalence of contact dermatitis. Moreover, an excess of crude protein in the diet will increase the nitrogen emission along with wet droppings which will result in a high prevalence of contact dermatitis (Gordon *et al.*, 2003). As for climate, a significant seasonal effect on the onset of broiler contact dermatitis with the highest prevalence during cold season has been observed (Ekstrand and Carpenter, 1998a, 1998b; Meluzzi *et al.*, 2008).

The prevalence and severity of foot pad dermatitis in broilers, affected by several factors, have been considered in the Directive proposal (European Commission, 2005) to assess the welfare condition of animals by classifying the feet in 3 categories as previously reported; however, in the final directive they were not taken into account.

Skeletal disorders

One of the most serious welfare problems is the high incidence of skeletal disorders, particularly those that lead to impaired mobility and lameness (SCAHAW, 2000).

Fast growing broilers, commonly reared nowadays, decrease locomotor activities and increase the time spent sitting, causing the onset of disorders in leg bones and cartilage which result in deformation of leg bones and gait anomalies. Both infectious (femoral head necrosis, synovitis and infectious stunting) and developmental disorders (bone deformity, dyschondroplasia, rickets) may impair broiler welfare. These abnormalities compromise the welfare of chickens that are unable to reach food and water and may, as a result, die from starvation and dehydration. A possible categorisation of welfare grade is based on gait analysis that ranks the degree of lameness on the basis of five scores (Kestin *et al.*, 1992). Birds with a score of 0 have a normal and agile walking style and inclination. Birds scoring 1 and 2 have slight defects of varying degrees that result in an abnormal gait but the defects do not seriously compromise the ability of the bird to move. Birds with a score of 3 or 4 have severe gait defects, and birds with a score of 5 are incapable of sustained walking. The gait score was criticised since it is considered a subjective test and the results depend on the age of the birds and the weight at which the subjects are selected. However, gait scoring surveys have shown that birds with a score of 3 or higher experience pain or discomfort.

Environmental enrichment

There have been various attempts to increase the activity of broilers by environmental enrichment, using litter, lighting programmes, toys, sequential feeding programmes, perches and elevated platforms. The availability of litter stimulated floor scratching behaviour in young chicks. This behaviour disappears as the birds grow older (Bessei, 1992). It is not known whether

the reduction of scratching behaviour is caused by the decrease in the general activity of older birds or by deterioration of the litter quality.

Provision of perches is considered to increase the activity of broilers. Significant increases in behavioural activities were observed when birds are provided with opportunities to climb, scratch and perch. The percentage of broilers using perches is generally low. It can be increased when the height of the perch is gradually raised and when high stocking densities are applied. Perches in broiler keeping systems produced breast blisters and keel bone deformation, and had no beneficial effect on leg conditions (Bessei, 2007).

Broiler behaviour and welfare assessment

Broiler chickens are reared for commercial purposes but they are living and sensitive animals and a wide range of needs must be fulfilled to safeguard welfare and prevent their suffering. Firstly, we have to know their behavioural repertoire which includes eating, drinking, sleeping, idling, preening, running, jumping, scratching, ground-pecking, wing flapping, wing or leg stretching, dust-bathing, agonistic encounters and vocalizing. During the first weeks of life they perform most of these activities standing, while during the second part of life they perform most behaviours whilst lying, and there is a significant decline in many activities, particularly in lame birds (Weeks *et al.*, 2000). Walking ability declines and lying increases with age. Several factors affect behaviour including genotype and diet; slow-growing genotypes are more active than fast growing birds being the latter selected by breeding companies to achieve very high live weight and good feed conversion efficiency. Broiler fed diets with low energy and protein contents are more active and spend significantly longer time feeding, ground-pecking and walking (Weeks, 2002). Light is a dominant factor in the regulation and control in the behaviour and health (Sanotra and Weeks, 2004). Diurnal rhythm, sleep and synchronized behaviour patterns are in part controlled by photoperiod. Continuous light without dark periods disrupts the normal sleep pattern and reduces the general level of activity. On the contrary lighting regimes that include a dark period increase broiler activity which, in turn, can affect leg health and bone growth (Classen, 1991; Sanotra *et al.*, 2002). Sanotra and Weeks (2004) state that dust bathing in chickens is an important comfort behaviour the function of which is the removal of surplus lipid from the plumage, the improvement of feather structure and the removal of ectoparasites. Most commercial broilers are reared under barren environmental conditions with no attractive stimuli and the litter is often wet and dirty which does not promote the motivation to dust bathe. Dust bathing activity also decreases with age and with the increase in stocking density. Fear is considered a state of suffering in domestic fowl which expresses it by freezing, escape or flight behaviour. Husbandry protects birds from predators and climatic conditions but the birds, since they have missed the mother hen teaching them to react in dangerous situations, show varying degrees of fearfulness in term of prolonged duration of tonic immobility.

Farm animal welfare is assessed by a combination of indicators of its physical and mental components and they can summarised as follows: physical indicators, such as leg weakness, foot pad dermatitis and feather conditions; physiological indicators, such as corticosteron level, heterophil:lymphocyte blood cell ratio, body temperature and temperature of comb and wattles, vocal indicators, such as the incidence of gakel

(gasp or other) calls; behavioural indicators, such as feather pecking, the incidence of displacement preening and stereotyped pacing, the tendency to range and walking style (Noldus and Jansen, 2004). From a practical point of view a reliable and flexible method to measure broiler welfare is required. Some authors (Sørensen and Sandoe, 2001) have proposed that measures should be: 1. simple to measure, 2. objective, 3. sensitive, 4. easy to measure under audit conditions and a valid reflection of animal welfare. Kestin *et al.* (1992) suggested a possible categorisation of welfare grade based on gait analysis ranks but this method was criticised since it was considered a subjective test. Later, Haslam and Kestin (2004) developed and evaluated broiler welfare in different farms and under different husbandry systems using the Unitary Welfare Index (UWI) which takes into account mortality, contact dermatitis incidence, severe leg weakness occurrence, stocking density, enrichment and emergency provision, severity of thinning and feed restriction programs and degree of feather pecking damage. The UWI produces a score that reflects the welfare states of broilers on the farm. Each house is scored from 1 (worst welfare) to 10 (best welfare) taking into account of all the levels of each of the welfare assessment measures. The average weighing was thus incorporated into the overall index.

Conclusions

In poultry production systems the welfare issues of broiler chickens have been less considered by the public opinion than those of laying hens due to the rearing conditions that allow birds to express their behavioural activities.

The EU Directive 2007/43 EC, which member states will bring into force by June 30, 2010, will ensure some improvements in intensive farming systems although some welfare indicators have not been taken into account. However, in practice for the Italian production system the new regulation will not substantially modify the current husbandry procedures, in particular with regard to stocking density (Meluzzi *et al.*, 2007; 2008).

Many studies have pointed out that welfare issues are affected by a combination of factors such as litter and air quality, stocking density, light regimen, feeding and management, as well as genotype. It is well documented that stocking density reduces growth rate as a consequence of heat stress, but housing conditions (litter quality, temperature and humidity) resulted to be more important than density itself. Very high stocking densities compared to very low densities reduce walking ability but the effects of commercial stocking density on other behavioural activities are inconsistent. The ventilation rate along with the adoption of increased air speed can play a key role in alleviating the negative effect of high stocking density and of wet litter. Litter quality has a direct influence on air quality (dust, ammonia, humidity) which can lead to respiratory diseases. Litter moisture is positively correlated to the incidence of foot dermatitis, one of the most important and investigated welfare indicators, although several other factors such as material, depth and condition of the litter, stocking density, feed composition and climate are involved.

The incidence of skeletal disorders, particularly deformity and fracture, are associated with the genetic selection for fast growing birds while the use of slow growing genotypes may reduce leg weakness and metabolic diseases.

In conclusion, considering that Europe is the unique continent that has ruled broiler chicken production, assuring thus mini-

mum welfare requirements to the birds, much more can be achieved to improve the welfare of broilers by adopting more stringent criteria for the control and monitoring of physical conditions of the environment as well as feeding and management practices.

REFERENCES

Algers, B., Svedberg, J., 1989. Effects of atmospheric ammonia and litter status on broiler health. pp. 237-241 in Proc. 3rd Eur. Symp. on Poultry Welfare, Tours, France.

Berg, C.C., 1998. Foot-pad dermatitis in broilers and turkeys-prevalence, risk factors and prevention. PhD Diss., Swedish University of Agricultural Sciences, Upsala, Sweden.

Berg, C.C., 2004. Pododermatitis and hock burn in broiler chickens. In: C.A.Weeks and A. Butterworth (eds.) Measuring and auditing broiler welfare. CABI Publishing CAB International, Wallingford, UK, pp 37-49.

Bessei, W., 1992. Das Verhalten von Broilern unter intensiven Haltungsbedingungen. Arch. Geflügelkd. 56:1-7.

Bessei, W., 1993. The influence of stocking density on performance, behaviour and health of broilers – A literature review. Arch. Geflügelkd. 57:97-102.

Bessei, W., 2004. Stocking density. In: C.A.Weeks and A. Butterworth (eds.) Measuring and auditing broiler welfare. CABI Publishing CAB International, Wallingford, UK, pp 133-143.

Bessei, W., 2006. Welfare of broilers: a review. World Poultry Sci. J. 62:455-466.

Bessei, W., 2007. Un quadro generale sul benessere del pollo da carne. Riv. Avicolt. 76 (5):30-34.

Blokhuis, H.J., Van der Haar, J.W., 1990. The effect of stocking density on the behaviour of broiler. Arch. Geflügelkd. 54:74-77.

Classen, H.K., 1991. Increasing photoperiod length provides better broiler health. Poult. Digest 50:14-28.

Cravener, T.L., Roush, W.B., Mashaly, M.M., 1992. Broiler production under very population density. Poultry Sci. 71:427-433.

Dawkins, M.S., Donelly, S., Jones, T.A., 2004. Chicken welfare is influenced more by housing conditions than by stocking density. Nature 427:342-344.

Ekstrand, C., Algers, B., 1997. The effect of litter moisture on the development of foot-pad dermatitis in broilers. Page 370 in Proc. 11th Int. Congr. World's Vet. Poult. Assoc., Budapest, Hungary.

Ekstrand, C., Algers, B., Svedberg, J., 1997. Rearing conditions and foot-pad dermatitis in Swedish broiler chickens. Prev. Vet. Med. 31:167-174.

Ekstrand, C., Carpenter, T.E., 1998a. Temporal aspects of footpad dermatitis in Swedish broilers. Acta Vet. Scand. 39:229-236.

Ekstrand, C., Carpenter, T.E., 1998b. Using a Tobit regression model to analyse risk factors for footpad dermatitis in commercially grown broilers. Prev. Vet. Med. 37:219-228.

Ekstrand, C., Carpenter, T.E., Anderson, I., Algers, B., 1998. Prevalence and prevention of foot pad dermatitis in broilers in Sweden. Brit. Poultry Sci. 39:318-324.

European Commission, 1991. Commission Regulation (EEC) of 5 June 1991 introducing detailed rules for implementing Regulation (EEC) No 1906/90 on certain marketing standards for poultry, 1538/91 EC. In: Official Journal L 143 , 07/06/1991, pp 11-22.

European Commission, 1999. Council Regulation (EC) of 19 July 1999 supplementing Regulation (EEC) 2092/91 on organic production of agricultural products and indications referring thereto on agricultural products and foodstuffs to include livestock production, 1804/99/EC. In: Official Journal, L 222, 24/08/1999, pp 1-28.

European Commission, 2005. COM Proposal 221 final. Laying down minimum rules for the protection of chickens kept for meat production. Home page address:http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2005:0221:FIN:EN:PDF

European Commission, 2007. Council Directive 2007/43/EC of 28 June 2007 laying down mini-

mum rules for the protection of chickens kept for meat production. In: Official Journal, L 182, 12/07/2007, pp 19-28.

Ferrante, V., Lolli, S., Marelli, S., Vezzoli, G., Sirri, F., Guidobono Cavalchini, L., 2006. Effect of light programmes, bird densities and litter types on broilers welfare. ID 10583 in Proc. 12th Europ. Poult. Conf. on CD-Rom, Verona, Italy.

Gordon, S.H., Walker, A.W., Charles, D.R., 2003. Feeding and broiler welfare. Measuring and Auditing Broiler Welfare – A Practical Guide. University of Bristol ed., Bristol, UK.

Grashorn, M.A., Kutritz, B., 1991. Effect of stocking density on performance of modern broiler breeds. Arch. Geflügelkd. 55:84-90.

Harms, R.H., Damron, B.L., Simpson, C.F., 1977. Effect of wet litter and supplemental biotin and/or whey on the production of foot pad dermatitis in broilers. Poultry Sci. 56:291-296.

Haslam, S., Kestin, S., 2004. Comparing welfare in different systems. In: C.A.Weeks and A. Butterworth (eds.) Measuring and auditing broiler welfare. CABI Publishing CAB International, Wallingford, UK, pp 183-195.

Jenkins, R.L., Ivey, W.D., McDaniel, G.R., Albert, R.A., 1979. A darkness induced eye abnormality in the domestic chicken. Poultry Sci. 58:55-59.

Kestin, S.C., Kowles, T.G., Tinch, A.E., Gregory, N.G., 1992. Prevalence of leg weakness in broiler chicken and its relationship with genotype. Vet. Rec. 131:190-194.

Kristensen, H.H., Wathes, C.M., 2000. Ammonia and poultry welfare: a review. World Poultry Sci. J. 56:235-245.

Lewis, N.J., Hurnik, J.F., 1990. Locomotion of broiler chickens in floor pens. Poultry Sci. 69:1087-1093.

Manfreda, G., Bertuzzi, S., Franchini, A., Franciosi, C., 1994. Immune response of chicken's supplemented with vitamin E in diet and/or vaccine. J. Nutr. Immunol. 3:51-57.

Mc Lean, J., Savory, J., Sparks, N., 2001. Welfare of male and female broiler chickens in relation to stocking density. pp 234-242 in Proc. 6th Europ. Symp. on Poultry Welfare, Zollikofen, Switzerland.

Meluzzi, A., Fabbri, C., Folegatti, E., Sirri, F., 2008. Survey on chicken rearing conditions in Italy: effects of litter quality and stocking density on productivity, foot dermatitis and carcase injuries. Brit. Poultry Sci. 49:257-264.

Meluzzi, A., Sirri, F., Betti, M., Bianchi, C., Franchini, A., 2004. Effect of stocking density, litter depth and light regimen on foot-pad disorders of broiler chickens. No. 1715 in Proc. 22nd World's Poultry Congr. on CD-Rom, Istanbul, Turkey.

Meluzzi, A., Sirri, F., Folegatti, E., 2007. Condizioni di allevamento e prestazioni produttive: gli effetti sulle performance zootecniche e sulla qualità del prodotto nell'allevamento del broiler. Riv. Avicolt. 76(6):18-22.

Meluzzi, A., Sirri, F., Petracci, M., Bianchi, C., 2003. Improving the rearing condition of chicken broiler: effects on performances and on carcass and meat quality. pp 414-420 in Proc. 16th Europ. Symp. on Quality of Poultry Meat, Ploufragan, France.

Newberry, R.C., Hunt, J.R., Gardiner, E.E., 1988. The influence of light intensity on behaviour and performance of broiler chickens. Poultry Sci. 67:1020-1025.

Noldus, L.P.J.J., Jansen, R.G., 2004. Measuring broiler chicken behaviour and welfare: prospect for automation. In: C. A. Weeks and A. Butterworth (eds.) Measuring and auditing broiler welfare. CABI Publishing CAB International, Wallingford, UK, pp. 267-290.

Proudfoot, F.G., Hulan, H.W., Ramey, D.R., 1979. The effect of four stocking densities on broiler carcass grade, the incidence of breast blisters, and other performance traits. Poult. Sci. 58:791-793.

Reiter, K., Bessei, W., 2000. The behaviour of broilers in response to group size and stocking density. Arch. Geflügelkd. 64:93-98.

Rennie, J.S., Whitehead, C.C., 1996. The effectiveness of dietary 25- and 1-hydroxycholecalciferol in preventing tibial dyschondroplasia in broiler chickens. Brit. Poultry Sci. 37:413-421.

Sanotra, G.S., Lund, J.D., Westergard, K.S., 2002. Influence of light-dark schedules and stocking density on behaviour, risk of leg problems and oc-

currence of chronic fear in broilers. Brit. Poultry Sci. 43:344-354.

Sanotra, G.S., Weeks, C.A., 2004. Abnormal behaviour and fear. In: C.A. Weeks and A. Butterworth (eds.) Measuring and auditing broiler welfare. CABI Publishing CAB International, Wallingford, UK, pp 71-77.

SCAHAW, 2000. The welfare of chickens kept for meat production (broilers). Report of the Scientific Committee in Animal Health and Animal Welfare. European Commission, Health and Consumer Protection Directorate General, Brussels, Belgium. Home page address: http://ec.europa.eu/food/fs/sc/scah/out39_en.pdf

Shanawany, M.M., 1988. Broiler performance under high stocking density. Brit. Poultry Sci. 29:43-52.

Shanawany, M.M., 1992. Influence of litter water-holding capacity on broiler weight and carcass quality. Arch. Geflügelkd. 56:177-179.

Sørensen, J.T., Sandoe, P., 2001. Assessment of animal welfare at farm and group level. Taylor and Francis, Dublin, Ireland.

Weeks, C.A., 2002. Some behavioural difference between fast and slow-growing strains of poultry. Brit. Poultry Sci. 43:S24-S26.

Weeks, C.A., Danburi, T.C., Davies, H.C., Hunt, P., Kestin, S.C., 2000. The behaviour of broiler chicken and its modification by lameness. Appl. Anim. Behav. Sci. 67:111-125.

Zubair, A.K., Leeson, S., 1996. Compensatory growth in the broiler chicken: a review. World Poultry Sci. J. 52:189-201.