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Welfare of broilers: a review

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Selection for fast early growth rate and feeding and management procedures which support growth have lead to various welfare problems in modern broiler strains. Problems which are directly linked to growth rate are metabolic disorders causing mortality by the Sudden Death Syndrome and ascites. Fast growth rate is generally accompanied by decreased locomotor activity and extended time spent sitting or lying. The lack of exercise is considered a main cause of leg weakness, and extreme durations of sitting on poor quality litter produces skin lesions at the breast and the legs. Management factors which slow down early growth alleviate many welfare problems. Alternatively it may be considered to use slow growing strains which do not have the above mentioned welfare problems. Since growth is a main economical factor, there are problems of acceptability of these measures in the commercial broiler production. Stocking density is a central issue of broiler welfare. It is evident, that the influence of stocking density on growth rate and leg problems acts through its influence on litter and air quality. High moisture content of the litter enhances microbial activity, which in turn leads to increase of temperature and ammonia in broiler houses, and thus, high incidence of contact dermatitis. High stocking density impedes heat transfer from the litter surface to the ventilated room. This restricts the efficacy of conventional ventilation systems in alleviating heat stress. Lighting programmes with reduced photoperiods are considered essential for the stimulation of locomotor activity and the development of a circadian rhythm in the birds. Extended dark periods, however, reduce growth when applied in the first weeks of age. Compensation occurs when the time of the production cycle is substantially increased. Various methods to enrich the environment have shown only moderate effects on the behaviour and physical conditions of broilers.

Keywords: broilers; welfare; behaviour; management; leg problems

Introduction

As a result of intensive selection for fast early growth, the poultry breeds and lines used for meat production differ substantially from egg producing breeds in their anatomy, physiology and behaviour. Feeding and management for meat production has been developed concurrently to exploit the genetic potential for growth. The time required to

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reach 1.500 g live weight was reduced from 120 days in 1925 to 30 days in 2005 (Albers, 1998). In order to exploit the high genetic potential for growth highly concentrated diets fed in pellet form and extended lighting programmes are required. The main welfare issues which have been addressed in the last two decades are closely linked with the fast early growth rate: high susceptibility to metabolic disorders and low locomotor activity. Among the management measures which have elicited criticism from the welfare point of view are in first line stocking density, litter quality and ammonia concentration in the air. In addition inadequate light duration and intensity and lack of environmental stimuli are considered to compromise welfare conditions. Most of the welfare problems are caused by multiple genetic and environmental factors and their interactions. Therefore it is generally not possible to strictly attribute particular problems to particular genetic or management factors. In the following the welfare problems are categorised in those which are *mainly* related to the genetic line and *mainly* to environmental factors.

The basic welfare issues in meat producing poultry are similar for the different species. As broiler chickens represent the major part of poultry meat in Europe and world wide, and most of the research on welfare has been done on broilers, the present overview is limited to chickens. It is expected, however, that more emphasis will be placed on the welfare of other poultry species in the future.

Genetic issues

HIGH EARLY GROWTH RATE AND DISEASES

Slow growing breeds show lower mortality from day-old to slaughter age, although the duration of the fattening period is shorter in the latter (Bauer et al., 1996). Causes of mortality related to fast growth are mainly Sudden Death Syndrome (SDS) (Gardiner *et al.*, 1988) and ascites (Maxwell and Robertson, 1997). With regard to SDS fast growing male birds are generally more affected than females (Grashorn *et al.*, 1998). Although the physiological mechanisms causing SDS are not fully understood, there is no doubt that growth rate represents the most eminent cause for this problem. As expressed in the name of the syndrome birds which are otherwise in good condition die within a short time. The range from the first sign of unrest until death was from 37 to 69 seconds (Newberry *et al.*, 1987). Hence suffering of the birds is restricted to that period. The welfare situation is different in the case of ascites. Ascites develops gradually and the birds suffer for an extended period before they die. The disease is characterised by hypertrophy and dilatation of the heart, changes in liver function, pulmonary insufficiency, hypoxaemia and accumulation of large amounts of fluid in the abdominal cavity (Riddel, 1991). The underlying problem of these symptoms is insufficiency of oxygen supply of the tissues of rapidly growing broilers, and both genetic and environmental factors contribute to the development of the disease. There exists genetic variation of the susceptibility to ascites between and within broiler lines (Deeb *et al.*, 2002). Broilers which are susceptible to ascites showed a reduced function of the tissues mitochondria (Cisar *et al.*, 2005). Environmental factors, which increase the demand for oxygen, such as low brooding temperature, or, which impair oxygen supply to the blood, such as high altitude, are known to increase the incidence of ascites (Mitchell, 1997; Julian, 2000).

SKELETAL DISORDERS

There is a high incidence of skeletal disorders in commercial broilers. Most of them are found in the locomotor system. Although diseases and nutritional deficiencies may play a role in the development of leg problems as well, the influence of growth must be considered as the main factor. Among the leg problems varus and valgus deformities, osteodystrophy, dyschondroplasia and femoral head necrosis play a major role. It has been found in experiments that the incidence of twisted legs and tibial dischondroplasia can be reduced by genetic selection (Sørensen, 1989). Because of the negative correlation between leg problems and growth rate this option may not be fully exploited in commercial breeding programmes. The leg abnormalities impair the locomotor abilities of the birds, and lame birds spend more time lying and sleeping (Vestergaard and Sanotra, 1999). Subjective gait scoring systems have been developed from 1 (normal gait) to 5 (high walking problems) to assess the incidence of leg problems in broiler flocks (Kestin *et al.*, 1992) and it has been assumed that the welfare of birds is poor when the scores are 3 or higher (McGeown *et al.*, 1999). Walking in birds with poor gait scores was significantly improved after treatment with analgesic and anti-inflammatory drugs. In self-selection experiments lame birds selected more drugged feed than intact birds (Danbury *et al.*, 2000). This lead to the assumption that leg problems in broilers are painful. The proportion of broilers with gait scores of >3 varies from 3 to 30 percent (EU, 2000). In a survey including 29 broiler flocks Sanotra *et al.* (2001) reported an average incidence of 30 per cent with a gait score of 3 or more, ranging from 12 to 55 per cent. The variation of the data may by explained by the effect of the scoring personal rather than differences in the flocks studied. There exist more objective methods of gait analysis in birds using video-tracking or foot-print analysis (Reiter and Bessei, 1997; De Jong *et al.*, 2004). These methods, however, are highly complicated and time consuming, and thus, not applicable when large flocks have to be controlled. It may be useful to develop a scoring system which reduces the influence of the scoring personnel.

Hock burns, breast blisters and foot pad lesions which may be summarised under the expression contact dermatitis, have been increased in broiler flocks during the last decades (Hartung, 1994). They are characterised by hyperkeratosis and necrosis of the epidermis of the affected sites. In an advanced stadium there are inflammations of the subcutis with degeneration of tissue. Secondary infections (*e.g.* E. coli) may further worsen the conditions of the birds. There is evidence that the contact dermatitis cause pain and thus is a matter of welfare. The incidence has found to be highly variable. Surveys in Sweden have reported an average prevalence of 5 to 10% (Elwinger, 1995; Berg, 1998) with high variation among flocks.

Contact dermatitis is obviously the result of the extremely long time of sitting and poor litter quality. Sitting and lying in fast growing broilers increase with age from 75% in the first week to 90% at 5 weeks of age (Bessei, 1992a).

LOCOMOTOR ACTIVITY

Locomotor activity is important for the ossification of the bones of growing animals.

There is a causal interrelationship between fast growth, low locomotor activity and leg problems. Thorp and Duff (1988) exercised broilers four times for 15 minutes per day starting at 8 days of age. This reduced the incidence of leg abnormalities from 33 days of age onwards. Reiter and Bessei (1994; 1995) have shown that the walking ability of fast growing broilers on a treadmill was higher than the voluntary activity under home pen conditions, and the increased exercise improved the skeletal conditions of the legs. The voluntary locomotor activity of fast growing broilers was significantly increased when a part of the body weight was alleviated by a special suspension device (Rutten *et al.*, 2002). This treatment improved bone characteristics as compared to the control broilers without exercise. The importance of exercise differs among breeds. In a recent experiment birds of a slow and a fast growing broiler line were brought to the same load on the legs by putting weight on the slow growing and alleviating weight of the fast growing lines (Djukic *et al.*, 2005). As before, the alleviation of weight from the fast growing lines increased locomotor activity and improved the leg bone conditions. Loading weight on the slow growing broilers decreased the locomotor activity. But the bone structure and walking ability was not significantly changed.

Environmental issues

STOCKING DENSITY AND LITTER QUALITY

Stocking density is a key issue for the economical result of broiler production. Current recommendations for stocking density in broilers differ widely by country and organisation (*Table 1*). There are plenty of experiments covering a wide range, from less than 10 to over 80 kg/m^2 floor space. Highest stocking rates of more than 80 kg/m^2 have been reported in caged broilers by Andrews (1972). In deep litter systems maximum stocking densities of about 50 kg/m^2 have been tested by Shanawany (1988) and Grashorn and Kutritz (1991). Most other experiments ranged between 20 and 40 kg (Scholtyssek and Gschwindt-Ensinger, 1983; Scherer, 1989; Wiedmer and Hadorn, 1998). There is a well documented reduction of feed intake and reduced growth rate when stocking density exceeds about 30 kg/m^2 under deep litter conditions. The effect of stocking density was reduced, when broilers were kept in cages (Scholtyssek, 1973) or on perforated floors in combination with under-floor ventilation (von Arkenau *et al.*, 1997). The negative effect of stocking density on growth rate was partially compensated by increased ventilation rates (Grashorn and Kutritz, 1991). These results lead to the assumption that problems of dissipating the metabolic heat may be the causal factor for the depression of growth rate. This was confirmed by a study on the temperature of the litter (Reiter and Bessei, 2000) (*Table 2*). The temperature measured 5 cm underneath the litter surface increased from 23.3 to 31.3 centigrade as stocking density increased from 19 to 40 kg per m^2. The temperature 1 m above the litter was about 22 centigrade and not influenced by stocking density. The assumption that the negative effect of stocking density on growth is caused by heat stress has been confirmed by McLean *et al.* (2001). They found that deep panting in broilers was increased when stocking density increased from 28 to 34 and 40 kg/m^2, suggesting more thermal discomfort from 34 kg onwards. The increase of litter temperature with increasing stocking density can be explained by different effects. Higher stocking density increases nitrogen and moisture level in the litter and thus, improves the conditions for the microbial activity. The transfer of heat from the litter surface to the ventilated space is inhibited when, at the end of the growing period, the total area of the floor is covered by the birds. Petermann and Roming (1993) measured the area covered by broilers in response to their body weight. Based on these data the percentage of the area covered by the birds was calculated. The area was totally covered at densities of 42, 45 and 48 kg/m^2 when the live weight of the broilers increased from 1.5 to 1.9 and 3.2 kg respectively.

There was no consistent trend of stocking density on feed conversion rate. While this trait was improved (Scholtyssek and Gschwindt, 1980; Shanawany, 1988; Grashorn and Kutritz, 1991; Cravener *et al.*, 1992) or not significantly changed in some cases (Scholtyssek and Gschwindt-Ensinger, 1983; Waldroup *et al.*, 1992), there was a significant deterioration reported by Scholtyssek (1974).

The occurrence of morphological changes, such as dermatitis including food pad lesions, breast blisters and soiled plumage have been reported as a result of high stocking rate. Most of the experiments have shown that the prevalence and incidence of these damages increased with increasing stocking rate (Weaver *et al.*, 1973; Proudfoot *et al.*, 1979, Cravener *et al.*, Gordon, 1992). It seems, however, that as mentioned before, the negative effects are the response to factors related to stocking density. When stocking densities from 10 to 35 birds/m^2 were studied, the incidence of dermatitis, leg problems

Table 1 Some recommendations on stocking density in the EU.

EU (2000)	Slaughter age, weight and ventilation rate / climatic condition should be considered; it appears that welfare problems are likely to emerge when stocking rates exceed 30 kg/m^2 This stocking densities should only be allowed when the producer is able to maintain air and litter quality
European Council (1995)	no fixed figures
a.v.e.c. (1997)	… stocking density depends on the housing capacity and quality of equipment and standard of management
Danske Fjekraeraad (1997)	maximum 40 kg/m^2
FAWC (1992)	34 kg maximum stocking; should not be exceeded at any time
Germany (Voluntary Agreement, 1999)	35 kg/m^2
Switzerland (Federal Law)	20 $birds/m^2$ or 30 kg $/m^2$ maximum
Sweden (Berg, 1998)	20 – 36 depending on management scoring

Table 2 Temperature in a broiler house at the end of a 6 weeks growing period in response to different stocking densities and different locations (height over litter surface and underneath litter surface) (after Reiter and Bessei, 2000).

Height over litter surface (cm)	**Stocking density (kg/m^2)** **19,4**	**30,0**	**40,2**
100	21,8	21,8	22,3
20	22,3	22,5	28,6
0	23,3	26,9	30,3
-5	23,3	26,9	31,3

and soiled plumage varied with humidity of the litter and ammonia concentration, but not with stocking density as such (Algers and Svedberg, 1989). In a large scale experiment with commercial farms using different breeds, management systems and stocking densities, it was confirmed that the management conditions (litter quality, temperature and humidity) were more important than stocking density (Dawkins *et al.*, 2004). Wet litter and ammonia have been found to produce breast blisters and skin lesions (Harms *et al.*, 1977; Proudfoot *et al.*, 1979; Valentin and Willsch, 1987; Weaver and Meijerhof, 1991; Grashorn 1993). Wet litter was also identified as main factor for foot-pad dermatitis by Ekstrand *et al.* (1997). In this context the type of the watering system showed a significant effect. Interestingly the incidence of foot-pad dermatitis increased with thickness of the litter layer.

It can be concluded that the influence of stocking density on the growth rate of broilers is acting through heat stress rather than physical restriction of the animals` space for movement. The results have shown that the growth depression which has been found with increasing stocking density was closely linked to problems of heat dissipation. The effect of stocking density on growth rate was reduced when the birds were kept on perforated floors, or on litter floors in combination with under-floor ventilation High stocking density impedes under conventional deep litter conditions, the heat transfer from the litter to the ventilated space and increased ventilation rate will not entirely alleviate the problem of heat stress. The negative effects of stocking density on different forms of dermatitis are mediated through poor litter conditions.

The effect of stocking density on locomotor and scratching behaviour in fast growing broilers was increased when stocking density was increased from 10 birds/m^2 in small groups, to higher densities in larger groups (Blokhuis and van der Haar, 1990; Lewis and Hurnik, 1990; Bessei and Reiter, 1993). In other studies using larger groups only there was no significant effect of stocking density on the behaviour with stocking densities varying from 10 to 25 birds/m^2 (Scherer, 1989; Bessei, 1992a). Since the behavioural activities of broilers decrease rapidly from 2 weeks of age onwards (Reiter and Bessei, 1995) the effect of stocking density may become less important in this regard.

ENVIRONMENTAL ENRICHMENT

The barren environment may contribute to the low behavioural activities of broilers. There have been various attempts to stimulate the behaviour by the enrichment of the environment. Various methods have been examined, using litter, light programmes, toys, sequential feeding programmes and perches or elevated platforms.

The availability of litter stimulates scratching behaviour. There is a sharp decline of scratching activity with growing age in conventional broilers (Bessei, 1992a). It is assumed that the deterioration of litter quality and the general decrease of the activity may be causes of this effect, but the relative importance of both factors has not been elucidated so far. The availability of litter did not modify locomotion as compared to an elastic perforated floor (Bessei, 1992b). Arnould *et al.* (2001) observed an increase in activity of young broiler chickens by providing strings and trays containing sand. The effect of the enrichment disappeared with increasing age. There was no effect of the treatment on the leg conditions. Mench *et al.* (2001) found significant improvements of behaviour activities on leg conditions of broilers, when they were reared in enriched pens with opportunities to climb, scratch and perch. Provision of perches is considered to stimulate the activity of broilers. The use of perches is depending on the height from the floor and the weight of the birds. Since heavy birds, which are considered to need the behavioural stimulation, are making poor use of the perch, their effect on the locomotor activity is rather limited. According to Martrenchar *et al.* (1999) less than 1% of broilers used perches (20 and 33 cm high) at low stocking density (11 birds/m^2). The acceptance of perches was increased to 10% when the stocking density was raised up to 22 birds/m^2. More perching (22%) could be achieved by Davies and Weeks (1995) who adapted the high of the perches, according to the growth of the birds, from 2.5 to 26 cm. Su *et al.* (2000) found no effect of perches on gait score. According to our own observations broilers used a ramp between feeder and drinker as perch, and spent more time sitting than broilers without ramps (Bessei, 1992 b). Barriers between feeders and drinkers have been reported to be used as perches (Bizeray *et al.*, 2001). But gait score was not improved. Some improvement of tibial breaking strength was reported by Balog *et al.* (1997) when ramps were placed between feeders and drinkers, but there was no reduction of tibial dyschondroplasia. Bokkers and Koene (2003) found that more slow growing than fast growing broilers used perches. The use of perches produced breast blisters and deformation of the keel bones.

Sequential feeding of diets containing different levels of lysine has been used to stimulate the activity of broiler chickens (Bizeray *et al.*, 2001). This procedure increased the foraging behaviour and locomotor activity in the chicks and improved leg conditions. At the same time, however, the body weight of the sequentially fed birds was reduced.

Briefly, environmental enrichment methods, which successfully stimulate the activity can improve the leg conditions and, thus, the welfare state of broilers. Perches are poorly used and do not increase the activity of the birds. While there was no impact of perches on leg conditions, they obviously increased the incidence of breast blisters.

LIGHT

Continuous light regimes allow the birds to feed continuously throughout the day. Earlier experiments have shown that growth rate and feed conversion were better under continuous light than under a natural day-night regime (Schutze *et al.*, 1960; Morris, 1967). Short light-dark-rhythms produced similar effects on the performance as continuous light (McDaniel, 1972; Buckland *et al.*, 1973; Kondo *et al.*, 1986). There was a positive effect of extended dark periods with regard to leg problems, mortality and metabolic disorders (Zubair and Leeson, 1996), but growth rate was reduced by this treatment. It is known that chickens, under extended dark phases, develop a circadian rhythm with increased feed intake before the beginning of the dark phase. It is also known that broilers start eating in the dark, when extended dark phases are introduced. It seems, however, that young broilers are not able to fully compensate for the shortened light periods. Thomsen (1989) kept broilers at 12:12 hours (light: dark) from 3 to 21 days of age and at continuous light thereafter. Growth rate was delayed under the 12:12 hrs light-dark cycle. Full compensation occurred at 49 days of age only. When intermittent lighting of 1 hour light : 3 hrs darkness have been compared with nearly continuous light (23 hrs light:1 hr darkness) compensation of growth rate was observed in males, but not in females (Buyse, *et al.*, 1996). Sørensen *et al.* (1999) found reduced incidence of tibial dyschondroplasia but no improvement of walking ability, when extended dark periods where provided between 3 and 21 days of age.

It has been shown that the light programme influences the level and diurnal pattern of the locomotor activity of the chickens. Simons and Haye (1978) measured the activity of broilers under continuous and intermittent light regimes. The total activity was higher when continuous light was given, and the activity was evenly distributed throughout the day. Under intermittent lighting conditions using short light-dark-cycles episodes of high locomotor activity occurred during the short light periods. These short periods of high activity did positively influence leg conditions (Simons and Haye, 1978; Thomsen, 1989). Reiter and Bessei (2002) measured the locomotor activity of broilers under quasi continuous light (23 hrs light : 1h dark) and 16 hrs light : 8 hrs dark. The average activity level in the light phase increased as the duration of light decreased. In the same experiment it was shown that broilers under 23 hrs light : 1 h dark did not develop a circadian activity patters, while those under 8hrs dark : 16 hrs light did. The development of circadian rhythms is considered an important indicator of welfare in domestic animals. Therefore clear day- night light programmes, which enable the expression of the diurnal rhythms, play an important role in the recommendations of animal-friendly livestock systems. It seems that more than one hour darkness is required for this purpose. 8 hrs of darkness obviously allow the development of the rhythm, but it is not known so far, whether this is the minimum time of light required. It has also to be considered in this context, that these results are based on the activity of groups of birds. It is generally known that the light cycles do not generate rhythms, but synchronise endogenous rhythms with different basic frequencies. It is possible that individual circadian rhythms even under continuous light. They may remain undetected in the group data because of lacking synchronisation.

The requirement for light was investigated by Savory and Duncan (1982) who trained broilers to operate a light switch. When the birds were offered to switch the light on in a dark environment (1 to 3 min of light per response) they realised a light period of about 20% of the time of day. When the programme allowed switching off the light in a light environment the time of darkness was less than 1%, and when they could switch the light on and off the duration of light was more than 80 percent of the time budget. Berk (1995) reported that broilers, when they were given free choice between a light and dark, the time spent in the dark increased with age.

Light intensity, wave length and source of light can influence the activity of broilers.

High light intensity (180 vs. 6 lux) increased the locomotor activity and reduced leg problems in 6 week old broilers (Newberry *et al.*, 1988). The positive effect of light intensity disappeared at 9 weeks of age. In another experiment using 2 and 200 lux tibial bowing was higher at the high light intensity (Gordon and Thorp, 1994). Despite the higher locomotor activity at high light intensity there was no negative effect on growth rate and feed conversion. This is in contrast to earlier results where high light intensity was found to reduce growth and deteriorate feed conversion rate (Proudfoot and Sefton, 1978). Prayitino *et al.* (1997) reported that high intensity of red light stimulated the activity of broilers. Boshouwers and Nicaise (1993) found that high frequency UV light produced higher activity in laying hens as compared to low frequency UV light.

High light intensities and particular light sources show some potential to increase the activity of chickens. Their impact on leg problems and welfare, however, has still to be investigated.

Chickens kept on continuous light (fluorescent and incandescent), continuous darkness or under dim light developed ocular enlargement and shallow anterior chambers (Lauber and Kinnear, 1979). The intraocular pressure was not influenced by the light treatment (Whitley *et al.*, 1984; Li *et al.*, 1995). Similar results have been reported in turkey poults by Davis *et al.* (1986). The continuous light effect on the chicken eye could be avoided by providing at least 4 hours of darkness in one block at the same time of the day (Li *et al.*, 2000). In most studies of light on the chicken eye chicks of layer strains have been used. Troilo *et al.* (1995) found significant differences in the reaction of different strains to different light schedules. Therefore the extension of the above mentioned results on broiler chicks must be considered with reservations.

Final conclusions

In conclusion the welfare problems of broilers are caused by factors which enable fast early growth, such as genetic background and extended lighting programmes. Fast growing lines under continuous light programmes decrease their locomotor activity and increase the time spent sitting with age. Low locomotor activity in combination with high early growth rate causes development problems in leg bones and cartilage, which result in deformation of leg bones and gait anomalies. High duration of time spent sitting on wet litter lead to skin lesions at the breast and legs, and contribute to deterioration of the welfare situation. It is assumed that these leg problems are painful. It has been proved that measures which reduce the early growth rate generally improve the welfare situation of broilers. The use of slow growing broilers as alternative to reduce growth rate in fast growing broilers has shown to be more efficient in reducing leg weakness and metabolic diseases. Stocking density influences welfare criteria mainly through litter and air quality, and its negative effects can be reduced by adequate management procedures. Moisture and temperature of the litter increase with age of the broiler and with increasing stocking density. This leads to thermal discomfort of the animals at the end of the growing period. Therefore it is recommended to monitor the physical and behavioural conditions of the birds rather than fixing data on maximum stocking density and other environmental factors.

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