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The negative effects of high stocking density on Broiler Chicken and Turkeys - a response to the proposed „all in one" program

Introduction

Broiler chicken (Gallus gallus domesticus) are the most numerous terrestrial animals farmed by mankind with an estimated annual production of about 40,000,000,000 birds in indoor intensive systems. Turkeys (*Meleagris*) are less widespread but are farmed commercially in many parts of the world. Mankind has never in its history had control of so many animals in controlled farming conditions. The true total global chicken population is not easy to determine, as the number of meat chickens kept in subsistence and small scale farms and for local consumption cannot be known. The major global producers are the USA, China, EU, and Brazil, but significant commercial production occurs in many other countries as well (FAO STAT). The genetic origins of the majority of birds reared around the world in indoor systems come from Cobb Vantress, Aviagen (Ros, Arbour Acres and Lohmann Meat strains) and Hubbard. (*Gallus gallus*) are characterized as being highly social with a clear dominance hierarchy when in small groups. Broilers can reach a body weight of around 2.3 kg in about 6 weeks and are increasingly housed at high densities (Estevez 2007).

Poultry, particularly broilers, have become a barometer for least cost production, and can be purchased in many supermarkets for less money per kg than some fruits and vegetables. With this quite astounding mass of animals in the 'care' of mankind, is it inevitable that the global chicken business will keep as its central philosophy - 'cheap as chicken' – and this philosophy places very significant production pressure on chicken farmers – one inevitable result of which is to absoultely maximise the number of animals which can be farmed in a given space. This philosophy is based on the logic of economics, but is not based on the balance of probabilities that chickens kept at the highest stocking densities have demonstrably reduced quality of life. What do chickens actually need? –nobody can truly say, but we can probably hazard some pretty good guesses. Chickens are sentient, capable of feeling pain and avoiding sources of stress and distress when they are given a choice. Free range and back yard birds show a large range of adaptive behaviours, but many of these behavious cannot be expressed in intensive indoor conditions. Society asks a lot of the chicken – we expect it grow very fat (egg to plate in 36 days), to be affordable, available and yet most people also hope that the industry behind their chicken dinner will be practically invisible.

In this report we focus on the evidence for poor animal welfare linked with high stocking densities. Animal welfare has been defined by The Scientific Committee on Animal Health and Animal Welfare SCAHAW (2000) to comprise both physical and mental health aspects – and in the case of space provided to animals – it is the effects of the physical environment (including space) on the birds physical AND mental wellbeing which must be considered. The

European Commission decision to limit stocking density is in conflict with the viewpoint of many producers who want to increase the number of birds housed to improve their profit (Meluzzi et al 2008). In this report we argue that for any country to move away from a policy which promotes and supports animal welfare concerns is a move toward an inevitable decline into farming based only on price competition – and that this is a one way trip toward lowest common denominator standards.

A short Chicken production history

The history of chicken intensification builds on the importance of three key ingredients - the move of rural people to towns and cities, electricity - enabling increased poultry house size, and use of fossil fuel to enable the harvesting and transport of feed from previously unachievable distance. The first birds with a lineage to the current birds reared on a commercial scale were imported from Asia to the USA and Europe can still be traced through existing lines such as the Java chicken. However, most chicken were reared in backyards and small flocks until the 1930's where expanding city populations in the USA created a demand for fresh poultry meat, and around cities like new York and Chicago, farms started to rear increasingly large numbers of birds in large outdoor flocks and housed in small group coops.

In the 1930's most farms did not consider the use of electricity for provision of services to animal houses, and so the use of automated systems for ventilation were rare. Farmers at this time were aware of the effects of poor air and house environment on their birds, and by the late 1930's farmers were beginning to experiment with keeping birds in more 'controlled environments'. By 1940 many birds were still given access to the outdoors but the 'range houses' which they used at night were becoming increasingly large and complex, with feeding systems, lighting and ventilation systems starting to develop as electricity became more widely used.

A quantum change in philosophy became apparent in the 1950's with the development of the first widely used fully housed poultry systems – and chicken rearing started to move entirely into houses. To enable this, systems to provide food automatically, to control ventilation and to regulate house temperature were developed, and by 1960, the house design used throughout the world was established, and would be quite recognisable to many poultry farmers today. As the birds moved indoors, people began to forget poultry as regular 'farmyard' animals, and to started to see poultry as a low cost food available in the food market, rather than at the farmers gate.

Chicken houses - what is provided for the birds?

If so many thousands of millions of broiler chickens are kept indoors – are these houses good places for them to live out their lives? Although there are variations on what constitutes a modern chicken house – there are some general recognisable features. Birds are kept on a floor covered in a thin layer of litter. The birds are kept under a roof. Sometimes there are windows, but mostly there are not, and feed, water, light, ventilation (and heat if required) are provided by automated systems in most farms.

Light is usually provided by electric lights, and in fully enclosed houses, light levels are generally quite low – at around 20 lux, just a bit more than the minimum you would need to read this article. In hot countries, where houses often have with mesh sides, or with pop holes to the outdoors, light levels can be very high. One reason commonly given for keeping birds at low light levels in European farms has been that this keeps them 'calmer' and so less likely to become excitable and to 'pile up' and suffocate. The vast differences in light levels seen in different poultry houses around the world, and the high light levels seen in many countries, make this argument a bit hard to follow.

In most large poultry houses artificial ventilation is required. Ventilation brings in fresh air and removes ammonia, carbon dioxide, carbon monoxide (from heating systems) and dust – and in countries with high temperatures, ventilation is combined with cooling in the form of evaporative cooling and tunnel ventilation to reduce house temperatures. Almost all current ventilation systems rely on electricity, and in some countries, electrical energy is one of the highest unit costs for poultry production. The control systems for the temperature, ventilation, light, feed and water are usually centralised and controlled by electronic sensors.

Chicken – a 'low margin per head' business – the animal welfare risks of increasing stocking density

As the intensive poultry house has developed, two major trends have emerged. The first trend is towards large farms, managed by smaller numbers of people. The second trend is toward a 'low margin per bird' but 'lots of birds' philosophy. Some farms in Northern Europe have 400,000 birds managed by two men. The man to bird ratio can fall to almost unbelievable levels. The farmer walks the houses looking for sick birds, keeps his eye on the monitoring system and plans the feed deliveries and the schedule for slaughter and re-stocking the houses. He becomes a skilled technician with vast numbers of animals under his technical care. Does this matter? If the automated machinery can ventilate and feed the birds, then is there an issue? When a man can farm so many animals, can it be realistic that the animals will receive a sensible degree of 'care'?

The growth rate of broilers

At the root of global broiler production has been a move toward higher productivity at a younger age. Some broiler birds can now reach 2kg weight by 33 days (see current growth performance at http://www.poultryhub.org/wp-content/uploads/2012/06/Ross308BroilerPerfObj2012R1.pdf) but this rate of growth is dependent upon very high technical competencies in the producer. If the broiler house environment falls short of the very highest management standards, then, because broilers are capable of enourmous growth potential – they have the capacity to suffer welfar insults if optimium feed provision or house conditions fail to be provided. This puts great pressure of the technical and resource capacities of broiler farms and is a legitimate cause for concern. The RSPCA (2013) have expressed this concern in their standards;

"The RSPCA is concerned about the practice of deliberately slowing the growth rate of fast growing broilers by adjusting either the quality or quantity of their feed to delay the time taken to reach slaughter weight, as can be the case when rearing fast growing broilers in free-range systems.

Broilers should be fed a diet that allows them to achieve their genetic growth rate potential. Therefore, when selecting broilers, their genetic growth rate potential should be as closely matched as possible to the time required to reach the desired weight at the time of slaughter."

Stocking density, animals per unit space or the space requirement per animal – which gives the best idea of the effects on the animal?

Today the birds in most houses can be found at a density of about 12 to 20 birds for every metre square (birds m^2). In broiler production language, this is usually converted to 'kg per metre squared' (kg/m^2) – removing the reference to the animal as an individual, and turning the discussion into one about how much 'biological mass in kg' a certain space can carry. Some studies have shown that not only is the space available a factor, but that the way in which the farmer cares for the animals is critically important (Jones *et al* 2005).

The space requirements of broiler chickens

Significant amounts of research has been carried out on the effects of space allowance on behaviour and health aspects of broiler chickens (Bessei 2006; Estevez 2007), but surprisingly little is known about broiler birds' preferences regarding space. Observations of junglefowl Gallus gallus (the wild ancestor of domestic fowl, *G. g. domesticus*) indicate that they form groups of 6 to 30 individuals, which range over an area of 3000 to 17 000 m^2.

The 'Broiler Directive' 2007/43/EC of 28 June 2007 sets stocking densities and characteristics for broiler production in the EU with;

1. A baseline permitted stocking density of $33kgm^2$
2. Provision that chickens may be kept at a higher stocking density provided that the owner

or keeper complies with the requirements Annexs I and II – this being 39 kgm^2 for producers achieving the requirements of the Annex's and with a derogation permitting a maximum stocking density of 39 kgm^2 plus 3 kgm^2 (42 kgm^2).

The Broiler Directive 2007/43/EC also has a number of practical implications for the poultry production industry, the enforcement bodies and the consumer – including requirements for keeper training (in physiology, feeding needs, animal behaviour, the concept of stress, practical aspects of poultry handling, catching, loading and transport, emergency care, emergency killing and culling and biosecurity measures), record keeping, poultry meat labelling, statutory inspections and provision of codes of management practice. The Directive also provides criteria for lighting patterns, ventilation, air quality parameters, humidity and temperature, litter quality, house noise levels, cleaning schedules, inspection intervals for animals, farm plans, alarm systems and feed withdrawal times. The competent authority is also directed to provide trigger levels based on post-mortem inspection to identify possible indications of poor welfare. The factors used to determine the capacity to stock at this maximum density in the EU are still under negotiation, but it is apparent that many countries have started data collection at the farm and at slaughter (EFSA, 2012) The measures commonly used by a range of countries in the EU include;

Measured at the farm

- Daily mortality
- Consumption of food and water
- Lameness
- Body weight
- Cleanliness of the feathers
- Mortality during the first 10 days
- Number of animals removed (culled) for leg problems

Measured at the slaughterhouse

- Injuries at the slaughter house (big wounds, broken wings or legs)
- Slaughter rejects (birds unfit for human consumption due to disease conditions)
- Deaths during transport (Dead on Arrival DOA)
- Pododermatitis
- Breast injuries
- Ulcers
- Breast deformities of turkeys

An example of the measures chosen to be used is that of the UK where two ‚levels' of measures have been in place since 2010 – these are known as Process 1 and Process 2 levels, and the measures and the thresholds used are shown on the tables below;

Table 1. *Trigger levels used for „process 1" in the UK. A ‚trigger' will occur if the condition is exceptionally high (exceeds mean + 6x standard deviation SD).*

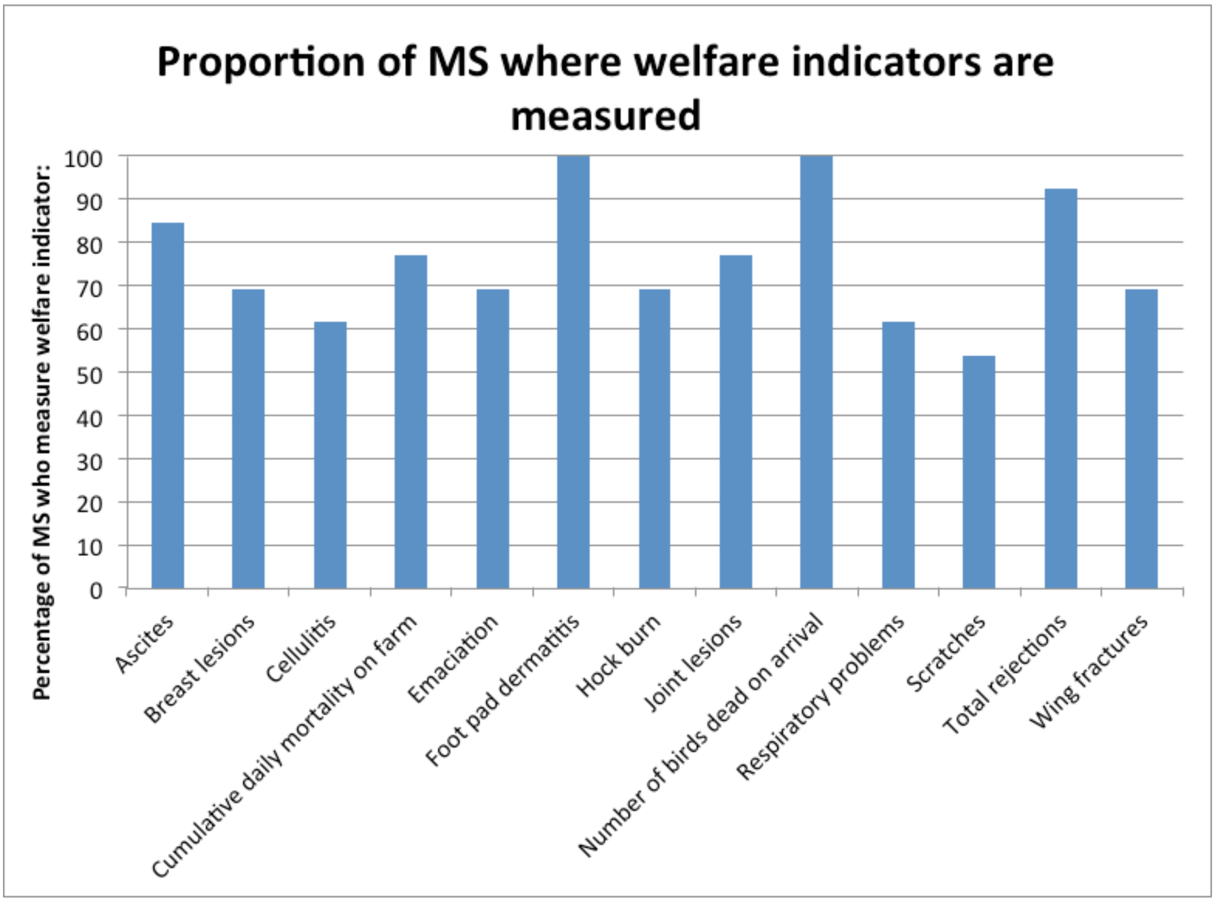
Post-mortem condition	Process 1 trigger level (%)
Ascites/Oedema	2.02
Cellulitis & Dermatitis	3.00
Dead on Arrival (DOA)	1.51
Emaciation	0.67
Joint Lesions	0.43
Respiratory problems	9.28
Total rejections	11.76
Cumulative daily mortality	11.85
Foot Pad Score (foot pad score is not a percentage but is a score of the severity and extent of lesions (between 0 and 200) based on scoring 100 feet)	167

Table 2. *Trigger levels used for „process 2" in the UK. A ‚trigger' will occur if the cumulative daily mortality is unusually high (exceeds mean +3SD = 7.37%) and, additionally, the rate of three or more post-mortem conditions is high (exceeds the mean).*

Post-mortem condition	Process 2 trigger level (%)
Ascites/Oedema	0.21
Cellulitis & Dermatitis	0.20
Dead on Arrival (DOA)	0.12
Emaciation	0.04
Joint Lesions	0.02
Respiratory problems	0.49
Total rejections	1.11
Foot Pad Score (foot pad score is not a percentage but is a score of the severity and extent of lesions (between 0 and 200) based on scoring 100 feet)	60

In the UK, here levels of the trigger level conditions exceed a certain threshold (as shown in Tables 1 and 2 above), the keeper of the animals and Animal Health are alerted. Where poor welfare is suspected, the Official Veterinarian can advise and support the keeper of the animals and Animal Health. The enforcement of action resulting from these trigger levels is by the local competent authority (Food Standards Agency in the UK) and these have inspection regimes and data handling systems (to communicate information relating to poor welfare between the slaughterhouse and the producer). Action may include a visit to the production site by an animal health officer, and the creation of an action plan to help resolve the issues identified. A summary of which measures a range of countries in the EU are using can be seen in the figure below;

Figure 1. *The proportion of EU member state (MS) competent authorites who use the measures described in their assessments for the purposes of the Broiler Directive 2007/43/EC. Data collated from 15 EU member states who made available information on their data collection practices.*



The 'all in one programme' for Austira intends to assess broiler welfare using three key measures;

A. Mortality
B. Death during transport
C. Foot pad injuries - pododermatitis

Comments on the choice of three measures and the limitations of this approach

A. Mortality (which should be broken down into ‚FOUND DEAD' and ‚CULLING')

a) Mortality data alone is a very blunt and non precise measure of welfare. Additional information is required to make judgements from mortality data. Mortality is defined as the 'uncontrolled' death of animals (as distinct from culling/euthanasia). The animals may die from, for example- septicaemia, respiratory disease, acute infection or dehydration. Any animal which is 'found dead' on the floor in the house, or out on the field is considered a mortality. Because the death of the animal in the case of true mortality is 'uncontrolled' – i.e. not in the control of the farmer, and the death may be result of prolonged disease or chronic conditions, then an animal which dies in the animal house (and is not actively culled) should be considered a severe welfare impact.

Culling – if a farmer sees a sick or injured bird, and takes rapid and decisive action to alleviate suffering – then this can be seen as a POSITIVE WELFARE action.

It is important to collect the following information regarding death on birds on a farm;

b) Number of birds FOUND DEAD (Mortality)

a) Causes of death (where this can easily be seen, such as for septicaemia, leg disorders or dehydration) for birds found dead

c) Number of birds CULLED by the farmer to prevent suffering.

B. Death during transport

DOA (Dead On Arrival) is very commonly recorded by slaughterhouses. It is a measure of two things;

a) the initial fitness of the birds to travel and

b) the transport conditions – and the capacity for the process of transport to cause death

Because DOA combines these two elements, it is not an accurate welfare indicator in that, if birds die in transport, it is often difficult to determine if they were in an unfit state for transport in the first instance as a result of – say, dehydration, poor body condition or systemic disease such as peritonitis or septicaemia. If the bird WAS in a fit condition for transport to slaughter – then the death in transport will have been caused by adverse transport conditions – such as high temperatures, low temperatures, wet, smothering by other birds, trapping of the bird in the transport crate (often trapping of the head), prolonged journey times or overtstocking of the transport module.

Sometimes the cause of high mortality at transport will be clear – for example in the case of high temperatures due to hot weather, and sometimes it will be less clear (for example, due to rough placing in the modules by the catching team).

DOA is a 'summative' measure in that it is a measure of processes which start at the farm – health status and body condition, then is affected by catching and handling at the farm and placing in the modules on the lorry, and then by the transport conditions (heat, cold, wet, air speed, distance, time), and finally by the time and conditions spent waiting at the factory in the lairage (waiting area) before slaughter. For these reasons, DOA is a very indistinct measure – as a clear cause of death is often not immeidately apparent. DOA is widely used as a 'welfare measure' because it is easy to count dead birds on arrival at a slaughterhuse, and it is clearly an economic as well as welfare concern – because no company wants to kill birds just before slaughter as this is the 'ultimate economic loss point'.

The Europan experience of using measures of this type to assess welfare status and to permit alterations in stocking density is variable at present – since the inception of the Broiler Directive

C. Foot Pad lesions

Pododermatitis is a very widely used welfare indicator in broiler production systems in the EU. Figure 1 (above) shows that 100% of EU competent authorites assessed have chosen to use foot pad lesions scores as a trigger level measure in their assessments for the Broiler Directive (2007/43/EC). The value of foot pad scores is discussed in detail in a number of the sections below.

Choice of measures to give a good 'overall assessment' of welfare?

EFSA (2012) compiled a listing of the Essential attributes, selection and uses of animal-based measures with particular respect to broilers.

"Animal-based measures used to assess broiler welfare are comparable with those used for any diagnostic test. We use these terms in specific contexts, but it is suggested that the criteria applied to diagnostic tests could also be applied to animal-based measures. For example fitness for purpose means that the test methods and related procedures must be appropriate (properly validated) in view of a specific purpose. Validation, in the context of this scientific opinion refers to the diagnostic performance of the measure i.e. diagnostic sensitivity and specificity. When combined this is sometimes referred to as accuracy, which in

a welfare context would be comparable to the overall correctness of an animal-based measure to identify a specific welfare consequence.

Robustness is another essential attribute of an appropriate animal-based measure for the assessment of animal welfare. It influences how the measure is affected by changes in the environment, who is taking the measure and when it is taken. It encompasses concepts such as repeatability and reliability, which are the agreement between repeated measurements of the welfare consequence on the same sample by the same (intra-observer) or different assessor (inter-observer) respectively. Maintaining repeatability and reliability over time requires training at regular intervals so that observers are "recalibrated" to a reference standard for the measure. This is very important to promote harmonization of recording to ensure consistency and accuracy of measurements. Whenever welfare outcomes vary over time, for example if they vary according to season, time of day, or time interval since last feeding, then the measures should be based on a representative time sample.

Welfare is a characteristic of the individual at a stated time, and most animal-based measures are taken on individual animals. However, in the case of broilers, individual animal data are normally aggregated to a flock, farm or population level, using summary measures, such as proportions or means, and interpreted against predefined threshold values. Whenever measures are taken from only a sample of all animals in the unit, it is essential that the sample should be unbiased and representative (e.g. in terms of sex, body size, location in the building etc.). It is important to specify how the sample of animals is to be chosen and the number of animals in the sample. The use of good operating procedures and reporting standards developed in health research should be applied to all animal-based measures.

In order to obtain information about the welfare of the birds in a flock, using animal-based measures, it is necessary to select a sufficient number of birds and samples that are representative for the purpose of the assessment. On-farm assessment has to be conducted at an appropriate time.

Animal-based measures: *Animal welfare measures - broilers*

Observations and measures: *from the animals made during the welfare assessment on-farm, ante- or post-mortem and are direct indicators (e.g. behaviour, clinical signs of injury or lameness, contact dermatitis). Some are veterinary procedures that can carried out only by a veterinarian or other authorised individual (e.g. post-mortem inspection – septicaemia, hepatitis, bruises, skin and lung lesions, ascites, contact dermatitis);*

Flock records *(body weight, disease records, mortality, etc.): are indirect and overarching indicators and are usually not taken from individual birds and may include records of animal-based measures obtained using automated methods (e.g. automatic weight recording). Automatic recording of activity has been developed under experimental conditions and should be tested under field conditions, because is a potential future method of considerable* *promise.*

Non-animal-based measures: (resource- and management-based):

Observations and measures: *of housing provided, management used (e.g. quality of bedding, stocking density, air quality, environmental temperature, efficiency of ventilation system), biosecurity (e.g. hygiene routines for stockmen and visitors, pest control; between flocks: removal of litter, cleaning and disinfection) and health control (prophylactic measures in terms of vaccination and antiparasitic treatment and medical treatment when justified).*

Documentation: *(e.g. biosecurity records, feed delivery, feeding programmes, lighting programmes, checking back up systems, bird origin and delivery, staff training)."*

Proposal to use 3 animals based measures – is this a robust choice?

The choice of just three measures (Mortality, DOA and Pododermatis) in the "all in one" programme on which to base a stocking density adjustment is not a strong decision, other countries have decided that a much larger range of measures is required to give confidence in the animal outcomes before judgements on stocking density are made. In line with EFSA guidance, other countries have elected to make a much more rigorous and wide ranging measures in their assessments (Figure 1). Animal 'welfare' is comprised of multiple components including physiology, behaviour and health. Production measures CAN be a relevant factor, and are commonly stated by producers as a key indicateo of good welfare citing the view that "*the animals would not grow if their welfare was not good, would they?"* However good production does NOT necessarily mean, or even ensure, good welfare, whereas decreased production is very likely to be a warning sign of conditions resulting in poor welfare. The motivation of animals to perform certain behaviours, and frustration of motivated behaviours is likely to be an important part of the welfare of an animal (Bokkers et al., 2007).

Chicken health and welfare and the link to stocking density

Broilers can also suffer a range of 'production' diseases, including lameness (sometimes called leg weakness), skin lesions on the feet (pododermatitis) and on the back of the scaly part of the leg (hock burn), skin damage due to poor litter (breast blister and cellulites) and also respiratory and heart disease affected by diet, genetic susceptibility and by house air and litter quality. Of these, lameness is probably the most widely seen disorder (Broom & Reefmann, 2005). The prevalence of broilers from moderate to severe (scores of 3 to 5 in a lameness scoring scale) close to the time of slaughter has been reported to range up to 26 percent (Kestin *et al* 1992), 30 percent (Sanotra *et al* 2003) and 27.3 % (Knowles *et al* 2008).

In general, the philosophy in intensive indoor reared chicken is to protect by vaccination and to make farms into fortresses which block access to most visitors – and so hopefully to uninvited pathogens and disease. This fortress farm philosophy may protect the animals from disease, but it makes the poultry business almost invisible. Houses containing 30,000 birds may have no windows and be virtually indistinguishable from commercial storage sheds. This, in my opinion, raises a simple philosophical dilemma; as the poultry business has disappeared inside, the mental and 'actual' contact between chickens and consumers has disappeared. There is no longer a clear view of what a 'chicken farm is' or even of how a farmed chicken looks and behaves.

Bessei (2006) in a broad reaching review of the implications of stocking density on broiler welfare states that; *"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.*
…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. 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.
…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. Stocking density influences welfare criteria mainly through litter and air quality, and its negative effects can be reduced by adequate management procedures."

Reduced growth rate and increased 'stress' indicators in broilers at high stocking density

It is well resognised that the growth rate of broiler chickens is suppressed when they are kept at high stocking density. This key finding is perhaps the most telling indicator that birds kept at high density not only do not experience good welfare, but also are subject to effects which actually compromise the function of growth.

The first point at which increasing density resulted in decreased growth was as low as 17 kg/m^2 (Thomas et al., 2004). Thomas compared the effects of four stocking densities on broiler welfare indicators (5, 10, 15 or 20 birds per m^2). The birds at the lowest density grew faster ($p<0.001$–0.01) and as the stocking density increased, so did litter moisture, the birds gait score increased (worsened), hock and foot pad burn scores increased (worsened) as did the feather cleanliness scores.

Sekeroglu et al (2013), studying birds kept at 3 stocking density groups (9, 13 and 17 birds/m^2) showed that a stocking density of 9 bird/m^2 was better for coefficients of broiler growth. In the 2000 EFSA report, it was noted that growth depression in boilers was estimated to start to occur at around 30 kg/m^2. In broilers, high densities have been associated with a decline in body weight (BW), feed consumption and conversion, flock uniformity, leg health, and increased frequencies of tibial dischon- droplasia, gait scores, carcass bruising and scratching, disturbances or exacerbated mortality related to heat stress (Estevez, 2007). The effects of high stocking density were particularly apparent when space allowances dropped below 0.055 m^2/bird, and Sørensen et al. (2000) found that the decline in body weight first could be measured when density fell below 0.0625 m^2, which corresponds to 15 birds/m^2.

Chickens were reared at 2 stocking densities, 12 or 17 birds/m^2 in a study by Guardia et al (2011) and it was found that the increased stocking density was found to negatively affect the feed conversion ratio (+3.1%) and depress the daily weight gain of broilers (−5.5%) during the later part of the growth (from 32 to 39 days). This study also showed that litter quality was also reduced at the higher stocking densiy and that this worsening of litter quality started as early as day 25.

In a study which examined the effects of stocking density on live performance, Dozie et al (2006) found that the growth of male broilers grown to 1.8 kg at 25, 30, 35 and 40 kg of kg/m^2 were adversely affected with increasing stocking densities by 35 days. They also found that litter moisture was higher as stocking density increased, and these authors concluded that increasing stocking density beyond 30 kg/m^2 adversely affected growth responses.

Simitzis et al (2012) assessed the impact of stocking densities of 12.6 or 27.2 kg/m^2. These authors found a significant reduction in growth performance, affecting final body weight and feed intake. Bessei (2006) and Estevez (2007) show that growth rate was reduced with high stocking density of above 30 kg/m^2.

Gomes et al (2014), state that “Overcrowding stress is a reality in the poultry industry”. Their 2014 study analysed the effects of overcrowding on growth and performance parameters, and on stress indictors including serum corticosterone levels, the relative weight of the bursa of Fabricius, plasma IgA and IgG levels, and gut macrophage activity and experimental Salmonella Enteritidis invasion. The results of their study indicated that overcrowding stress decreased performance parameters, induced enteritis and decreased macrophage activity and the relative bursa weight in the broiler chickens they studied. Simsek et al (2011) evaluated the effects of different stocking densities (22.5, 18.75, 15, 11.25, 7.5 broilers/m^2. The daily weight gain and feed intake of the birds was reduced as stocking density increased (P5 0.001) and these authors concluded that feed consumption was adversely affected by stocking density resulting in poor growth and poor bone mineralisation. Guardia et al. (2011) also found that an increase in stocking density was linked to a reduction in the composition and effect of digestive microbes. An alteration in the content of gut microbes may be detrimental to health.

Heat stress and ability to regulate temperature is affected by high stocking rates

Air temperature (and humidity) is affected by stocking density, season and ventilation system. As litter temperature rises with increasing stocking density, the ability for the birds and the litter) to lose heat passively is impaired (Reiter and Bessei, 2000). The initial response of the broilers to heat challenge is to reduce their activity levels, through reduced walking, and reduced standing and preening (Lolli et al., 2013). Heat stress has been found to decrease feed intake and mortality can be significantly increased with high stocking density under hot conditions. Pettit-Riley and Estevez (2001) found mortality due to heat stress was significantly higher at densities above 0.066 m^2 (15 birds/m^2).

Abudabos et al (2013) examined the thermophysiological parameters in Ross male birds of 43 days of age at different stocking densities (26.5 kg/m^2 and 45.0 kg/m^2). High stocking density broilers experienced pronounced elevations of their body temperatures, and the authors indicate that high stocking density created an impediment for dissipation of body heat and consequently resulted in significantly increased risk of heat stress in the animals kept at higher stocking density.

Panting can be an efficient physiological mechanism for heat dissipation in broilers (Lolli et al., 2013). In a study comparing different stocking densities, it was shown that panting in six week old broilers significantly increased when stocking density was increased from 28 kg/m^2 to 34 and then to 40 kg/m^2, indicating that thermal discomfort can become a key problem at high stocking densities at towards the end of the growing period (McLean et al., 2002).

Adequate ventilation rates are required to provide effective temperature and humidity control within the house (Jones et al., 2005) and can also be important in preventing litter from becoming wet and sticky. At high stocking densities, not only do the birds have huge heating capacity due to the high concentration of their biological mass – but the physical presence of birds reduces or even prevents airflow at low levels in the house, and this can result in both increased risk of heat stress, but also in much increased risk of poor litter conditions.

Air pollutants increase as density increases

Ammonia is produced in the litter by microbial decomposition of nitrogenous substances. Ammonia levels of 10 ppm or more in the broiler house can damage the lung surface (of both the birds and of humans) and increase the susceptibility to respiratory diseases. In broiler houses, the most important factors influencing ammonia production are air temperature, ventilation rate, humidity, feed composition, age of the litter, litter pH, moisture content, litter type, stocking density and the age of the birds. Increases in stocking density will directly affect litter pH, the amount of water added to the litter through faeces, the direct input of nitrogen through faeces, and the potential for increased ammonia production and higher inspired ammonia levels is directly linked to bird numbers in a given air spance – i.e. to stocking density.

Dust in broiler farms is produced from feathers, skin scales, feed and the litter. The largest particles (>5 µm; the inspirable fraction) are mostly filtered by the upper airway, smaller particles (the respirable fraction) can reach the trachea, and cause irritation, mucous membrane damage and reduced feed intake. The very smallest particles (inhalable dust) can travel down deep into the lungs. They can carry bacteria, viruses and fungal spores into the lungs causing infection, as well as lowering respiratory capacity and oxygen uptake.
The amount of dust produced is linked to the number of animals, the amount and quality of the food fed, and the quality of the litter. Stocking density affects both the levels of production of dust, but also the capacity of ventilation systems to carry this dust out of the poultry house (where it adds to aerial pollution). Inspirable dust concentrations of up to 10 mg/m^3 have been commonly found in the air of broiler houses at the end of the growth period, and these levels are about 2.5 times higher than the allowed concentration for workers in Germany (4 mg/m^3).

Behavioural capabilities more limited at high stocking density

Increased stocking density may restrict litter directed behaviours and locomotion. Aspects of mobility may be compromised by stocking density, even at relatively low densities, and Buijs et al (2009) found a steep decrease between 6 and 23 kg/m^2. In a study which measured the amount of floor area requirements of six-week-old broilers (Bokkers et al 2011), photographs were taken of overhead projections of broilers (2.468 kg on average) kept in pens of 8 birds (low density) or 16 birds (high density) per pen and the body space 'requirement' for seven behaviours was measured from these photographs. The Results indicated that at the higher density, the birds were 'compressed'. These authors discussed what it is that makes an individual space requirement for an animal along the lines suggested by Petherick (1983). The state that an animals requires;

a) Body space - which is the static space needed for the body itself.
b) Behavioural space - which is the space an animal needs to express behaviour in an individual context.
c) Bocial space — the space needed to allow animals to interact or avoid interactions with conspecifics.

This analysis of basic body-space measurements, lead to the conclusion that, whenever birds are kept at more than 15.7 birds m^2, compression, ie. restriction of the 'normal space requirement for basic behaviours' will happen.

Marchewka et al (2013) state that the welfare of broilers can be challenged by multiple factors such as by their genetic potential for growth, decline of environmental quality, poor management, or excessive density which may result in contact dermatitis, metabolic, skeletal and muscle disorders, or behavioral abnormalities. In a study examining the effects on a range of behaviours of stocking densities of 18, 25, 35, 40 kgm^2, Knierim (2013) found that, at the lower stocking densities, there was significantly more running, wing-leg stretching, scratching in the litter, and wing lifting. The results of this study indicated that the behavioural restrictions seen at the higher stocking densities correlated with increased risks for footpad alterations and lameness.

Evidence for a decreased mobility with increasing density is supported by studies on commercial farms (Dawkins et al., 2004; Knowles et al., 2008). Walking episodes were found to be shorter at higher densities (Hall, 2001; Febrer et al., 2006; Buijs et al., 2010; Lewis and Hurnik 1990), with birds at higher density covering less distance in a given periodof time (Leone and Estevez, 2008). These finding suggest that it becomes harder for the birds to move around as density increases.

Bokkers et al. (2011) showed that broilers are "compressed" when kept at a stocking density of 16 $birds/m^2$ and above, as a result of the barrier effect that hampers movement and dispersion of the birds on a floor space (Estevez, 2007). Collins (2008) showed that was a trend for the nearest broiler chickens (neighbours) behaviour was associated with the behaviour of the surrounding flock. In 57.1% recorded instances, nearest neighbour behaviour matched the most common overall flock behavior, and that the behavior of the flock was influenced by stocking density. The rate of walking, long preening and standing behaviours were significantly altered in flock at higher densities in these studies.

Increased levels of disturbance of resting behavior and decreased extent of walking was found even in large scale commercial studies in which it might be at first assumed that management and environment influences would be the most significant affectors of bird behavior (Dawkins et al., 2004; Febrer et al., 2006).

Poor activity levels – forced sitting

Bessei (2006) considerd that broiler chicken welfare problems often have multiple causes. These include the genetics of the bird which - influences their behavioural propensity to activity and decrease their locomotor activity, results in increased skeletal abnormalities, and results in high body weight gains. Bessei also concluded that the lighting programmes used commercially decreased locomotor activity, shifting the behavior of the birds towards "extreme sitting levels" - which, in combination with wet litter, cause pododermatitis and hock burn.

Leone & Estevez, 2008, showed that movement patterns in the domestic fowl are primarily determined by enclosure size, followed by density. When housed in enclosures of equal size broilers birds appeared to use similar total amounts of space as indicated by net displacement and the size of the minimum convex polygons, irrespective of density or group size. However, inter-individual distances and rate of movement as measured by nearest-neighbour distance and total distance travelled per observation period were clearly affected by density, possibly due to a barrier effect (Newberry & Hall 1990).

'Disturbance' of resting and other behaviors at higher stocking densities

Broilers are increasingly disturbed by each other, and hence potentially find it more difficult to find undisturbed rest as density increases (Hall, 2001; Cornetto and Estevez, 2001; Dawkins et al., 2004; Febrer et al., 2006; Buijs et al., 2010; Ventura et al., 2010). It is apparent from the studies that there is not a 'critical density' for increased disturbances, but that the rate of disturbance increases gradually over a wide range of densities. It has been suggested that disturbance due to increased stocking rates causes fragmentation of preening and resting activity and Chickens jostled each other more. (Hall, 2001; Buijs et al., 2010; Buijs et al., 2011b).

Buijs et al (2010) found that higher flock densities led to shorter sitting and preening bouts (P = 0.024 and P = 0.013), and a decrease in walking bout length as the weeks of production progressed (density/week, P = 0.025). These studies also showed that birds adjusted their sitting or lying posture more often at higher densities (P < 0.001), indicating an increased number of disturbances. Buijs et al. (2011b) found that broilers stocked at a target weightof greater than 15 kg/m^2 avoided each other, suggesting that they experienced the close proximity of other birds at the higher stocking densities aversive. Buijs et al (2011a) also suggested that broilers in groups ≥19 birds per 3.3m^2 (equivalent to 15 kg/m^2) started to experience the proximity of other birds as aversive during the last 3 weeks of rearing. The preference for birds to sit in proximity to the wall of the poultry house occurred when overall density went above 12.1 birds/m^2. Because of the occurrence of 'wall sitting' at times of peak flock density, avoidance of disturbance seems the most likely explanation for wall preference. Buijs (2011) suggests that increased use of the wall area may be an indicator that birds are experiencing crowding.

Simitzis et al. 2012 showed that higher stocking densities were associated with decreased locomotor activity and increased physiological (Heterophil:Lymphocyte ratios and increased bursa weight) and oxidative glutathione concentrations, and with reduced:oxidized glutathione ratios – these all being indicators of stress responses.

Buijs et al (2009) looked at a number of welfare parameters for birds stocked at 6, 15, 23, 33, 35, 41, 47, and 56 kg/m^2. They found that stocking density negatively influenced leg health (P = 0.015) and footpad and hock dermatitis (P < 0.001) and tended to influence fearfulness (P = 0.078). They showed that leg 'health' (Gait score) showed a steep decrease from 6 to 23 kg/m^2, and that hock dermatitis rose from 35 to 56 kg/m^2. These authors brought together their measures in a 'score integration' which showed a decrease in welfare as density increased (P < 0.001). The lowest 2 densities (6 and 15 kg/m2) scored better scores than the mid densities (23, 33, 35, and 47 kg/m^2) and scores for all the lower densities scored better than the highest density (56 kg/m^2).

15 birds per m^2 – a critical threshold for broiler chicken welfare

As seen in a number of the papers and studies discussed previously in the sections of this report - the effects of increasing stocking density become more apparent and severe at stocking above 15 birds/m^2 at slaughter age. If a bird weighs 2 kg at this age, this equates to 30kgm^2 or 0.067 m^2 per bird.

Turkey stocking densities

Work by Ellerbrock and Knierim (2002) on German turkey production showed that at commercial stocking densities there is a link between the weight of the birds and the space required to allow bird body space to be accommodated and permit some basic bird behaviours. The available space for turkeys was found to vary dependant, and to a degree, on the body shape of the birds, with tall lightly built birds having more available space than smaller more heavily built birds. These authors noted that stocking density has a clear impact on plumage condition, with birds at high stocking density and older age commonly having single tail feathers or no feathers on the tail at all. These authors also noted that older and heavier birds may need more space for social behaviours as they become increasingly aggressive with age and so may need more space for behavioural thermoregulation and heat dissipation (see section on broiler heat dissipation needs with increasing stocking density). These authors also note that if stocking densities are reduced – this leads to less aggressive behavior, more distbathing, cleaner amd more complete plumage, and less damage to breast skin and swollen joint lesions.

The QBT (Quality British Turkey) standard (available at http://www.poultrypassport.org/wpcontent/uploads/2013/06/2013_qbt_agriculture_standards_v1final_bpc.pdf) shows stocking density calulations based on live weight and floor space. A = k.W2/3 (where A is the space required in m^2, k is the co-efficient 0.0459 and W is liveweight in kg), applied to various liveweights.

This standard permits stocking density of 59.1kg/m^2 when the individual bird weighs 20kg. This is a strikingly high density of animals per m^2, as nearly 3 20kg birds (2.95) can be kept in 1 m^2. In contrast, and based on concerns about the limitation of high stocking density on Turkey behaviour and feather and skin conditions, the RSPCA standards (RSPCS 2007 available at http://www.rspca.org.uk/sciencegroup/farmanimals/standards/turkeys) state that the stocking density of Turkeys must never exceed 25kg/m^2 and must be calculated based on the available floor space area.

Enrichment of the farm environemt

Environmental enrichment is not a new concept and is often considered when housing captive zoo animals, as it is seen to have positive effects on welfare, for example reducing stress hormone levels and improving behavioural responses to stress in brown capuchins (Boinski *et al.*, 1999) and reducing stereotypic behaviour and encouraging natural behaviour patterns in several species. Despite the evidence supporting the use of enrichment and the increasing concern for farm-animal welfare from animal welfare organisations, consumers and producers, to date surprisingly little research has been done into the effects of environmental enrichment on poultry welfare.

The standard broiler chicken in the EU is intensively reared in indoor barns. Generally, these barns are without natural light, with automated systems controlling intermittent light and dark periods (Bizeray et al, 2002). The poultry house floor is covered with litter material such as wood shavings or straw. Other than the feeders and drinkers, the birds have little to interact with within their surroundings.

Simsek et al (2009) and Shields et al (2005) concluded that environmental enrichment incluiding changes or maintenance of useabel litter bedding substrate can improve physiological health through an increase in activity levels, and showed that enrichments provided exercise to strengthen muscle and bone resulting in an improvement in leg health. Baillie et al (2013) assessed the effect of natural light and access to straw bales on activity levels and leg health (gait score – walking ability) in commercial broiler chickens. The percentage of time spent lying was significantly reduced by the provision of natural light (P , 0.01). There was an interaction between treatments in average gait scores, with higher gait (poorer walking) scores in the groups with no natural light and no access to straw bales. These authors concluded that environmental modifications have the potential to increase activity levels and improve the leg health of commercial broilers and that the light environment "appears to be particularly important in this respect".

In some countries, as a result of interst from retailers (and in response to public intrest) the standards applied to farms which aupply some retailers are starting to require enrichment in broiler houses, for example, use or perches, pecking blocks, straw bales, and the use of windows to provide natural light. Examples of the retailer and supplier initiatives and standards can be seen at;

http://www.fwi.co.uk/articles/28/09/2011/129295/morrisons-to-raise-basic-chicken-welfare-standards.htm http://www.freedomfood.co.uk/media/34115/rspca_welfare_standards_for_chickens___november_2013_web.pdf

Walking ability and the barrier effect – reduced ability to move freely

Dawkins et al (2013) state that "When healthy, normal walking becomes unusual within a flock, that is a sign that the welfare of the flock as a whole may be reduced."
Knowles et al (2008) assessed the walking ability of 51,000 birds, representing 4.8 million birds within 176 flocks and obtained information on approximately 150 different management factors associated with each flock. These authors found that higher stocking density at the time of assessmen was one of the significant risk factors for increased lameness (increased flock gait score) in this large study. They summarized the interaction between stocking density and lameness score as; *"For every 1 kg/m2 increase in stocking density as measured at the time of the flock assessment, across a range from 15.9 to 44.8 kg/m2, there was a 0.013 deterioration in flock gait score."*

In a study in Danish flocks, the proportion of birds with gait scores 4 and 5 (severely compromised walking ability) were significantly higher when space allowance dropped to or below 0.0625 m^2/bird (Sørensen et al., 2000). At high densities Arnould and Faure (2003), Dozier et al. (2005b) and Sørensen et al. (2000), showed an increased incidence of foot and hock burns. (Sørensen et al., 2000) showed that increased foot burns and hock biurn correlated with increased (worsening) of gait score. The increased average gait score (worsening of walking ability) noted by these authors at higher stocking density may be related to a reduction in real exercise, or in the 'capacity to exercise' and this is supported by the reduced 'distance traveled' by broilers noted at high densities (Hurnik and Lewis, 1991; Estevez et al., 1997). It is likely that the differences in walking behavior are related to reduced movement resulting from the barrier effect of other birds (Newberry and Hall, 1990).

Litter quality

Chickens in almost all intensive systems live their lives on a bed of litter. When they are first placed in the house, the litter is clean and dry. Soon, the litter mixes with faeces and feathers and skin dust, and with water spilled from drinkers and moisture absorbed from the air. After a few days, litter has become a living thing – it decomposes and changes its structure, and it contributes to the temperature of the house and to the gas and dust of the broiler house atmosphere. Litter is not a simple 'bed' for birds, it is where they forage, dust bathe (if they can) and rest. In the absence of perches (most systems do not have perches) the birds are in contact with the litter for the entirety of their lives. Litter is THE most important human influenced factor for the most populous animal under mans control - because it is so influential in the quality of life for such an enormous number of animals.

In good litter, birds can rest without becoming dirty, and they can care for their feathers by preening. If the litter is dry and deep, birds can, and will, dust bathe, and can forage and scratch - although there is nothing for them to eat in litter. Poorly managed litter can make the birds cold, wet and dirty, can prevent them from cleaning themselves and preening, they cannot dust bathe, and contact with the litter can produce skin lesions on the feet, hocks and breast. Litter can become wet and sticky, or caked with a hard surface and even oily or greasy. Conversely, litter can also become very dusty – making the house atmosphere damaging to the birds lungs and respiratory system. (Dawkins et al., 2004) found that under commercial conditions, litter was wetter when birds were housed at higher stocking densities. Litter 'quality' is at the heart of a chicken's life experience – and, unfortunately, in practice and on many farms, litter quality is often poor.

The importance of good litter quality for the welfare of broilers birds is very well recognised. Litter quality influence dust levels, ammonia levels, house humidity, and hence the respiratory health of the birds (and the human operators in the poultry house). Litter quality directly influences the skin of the birds, causing foot, hock and feather conditions if the litter quality is poor. Moisture levels may be affected by the choice and quantity of litter material, the type of drinkers, water consumption and water spillage, ventilation rates, air flow patterns in the broiler house, the 'blocking' nature of birds close to the floor preventing movement of air, the air temperature, stocking density, bird activity levels and bird age. Additionally, diseases which influence the compositiuon of the litter (diarrhoea), and the composition of the diet greatly affect the amount of water consumed and the component of the litter that is faecal moisture. The moisture content of litter is positively correlated with the incidence of foot pad dermatitis (Shepherd and Fairchild, 2010), and is considerdd by many to be a very clear and important welfare indicators (Meluzzi and Sirri, 2009), and was included in the Welfare Quality assessment system (Welfare Quality 2009).

Wet litter is well recognised major risk factor for contact dermatitis (Shepherd and Fairchild, 2010) and periodic wet litter conditions were reported by 75% of farmers in a study by Hermans et al. (2006). When litter is of good quality this enables the birds to perform behaviours including resting, sleeping and standing on litter with reduced risk of skin conditions, and to perform scratching and dust bathing.

Dustbathing

Dustbathing is a highly motivated behaviour in *Gallus gallus domesticus* and broilers may show dustbathing on wood shavings, the most commonly used litter substrate in modern broilerproduction (Bokkers and Koene, 2003a). However the inability of commercial birds to dustbathe because of poor litter quality or as a result of physical obstruction by other birds at high stocking density potentially has importance for the welfare of the birds.

Foot, hock and skin conditions and their link to stocking density

Contact dermatitis is a widespread problem in European broiler production (EC, 2000), with lesions occurring on areas of the body in prolonged contact with the litter, most commonly on the feet (foot pad or podo-dermatitis) but also on the hocks, commonly described as hock burns, and breast muscle, particularly in heavier and lame birds (Kristensen et al., 2006).

Meluzzi (2008) indicates that stocking density is a critical 'concern' as it is linked to the increases in flock mortality, to the worsening of litter conditions, and to an increase in health problems including leg disorders and contact dermatitis, in particular foot pad dermatitis, hock and breast burn. Foot pad dermatitis (FPD) (Foot pad dermatitis score - FPDS) is a contact dermatitis affecting the plantar region of the feet. The lesions can develop rapidy, often in the first two weeks of production. Foot pad dermatitis is accompanied by discolouration of the skin, and progressive developement of ulcers with inflammatory reactions of the subcutaneous tissue and hyperkeratosis of the skin. Foot pad dermatitis can lead to a pain and to decreased walking ability and reduced growth rate through reduced feeding mobility. A large number of studies have shown that litter quality links to foot, hock and skin and feather health and that there is increased potential for deterioration of litter quality with increasing stocking density (Sorensen et al., 2000; Hall, 2001; Thomas et al., 2004; Dozier et al., 2006; Buijs et al., 2009; Villagra et al., 2009; Ventura et al., 2010). An analysis by Kyvsgaard (2013) showed that foot pad lesion scores increased when the litter quality was evaluated as poor. Villagra et al (2009) state that high stocking density contributes to poor litter quality, high ammonia production and heat stress. In a study with high and low density flocks these authors found that stocking density was found to significantly affect Foot-pad dermatitis (significantly higher for High Density flocks).

Haslam and co-authors (2007) studied data from 149 broiler farms taken during the days just prior to slaughter. Birds were examined at the slaughterhouse for contact dermatitis lesions. Foot pad dermatitis score (FPDS) and hock burn score (HBS). These authros found that for every one-point increase in litter score there was an associated 0.326 increase in mean FPDS, and that for every one-point increase in flock mean HBS there was an associated 0.411 increase in mean FPDS. Foot pad lesions can also impact on meat hygiene, as foot pad lesions may be a gateway for bacteria. High stocking density has been shown to increase the incidence of foot pad dermatitis, hock and breast lesions in a number of studies (Dozier et al., 2006; Bessei, 2006). Cravener et al (1992) examined birds housed at 0.05, 0.07, 0.09, and 0.11 m^2 per bird. Under 0.05 m^2 per bird, a higher percentage of breast blisters and ammonia burns (30%) was observed than at other densities. Lowered body weight and decreased carcass quality was seen in birds raised at 0.05 m^2 per bird, suggesting (as noted by the authors) that these birds were stressed.

Buijs et al (2012) studied the effects on skeletal health in broiler birds stocked at densities of 2.4, 5.8, 8.8, 12.1, 13.6, 15.5, 18.5, and 21.8 birds/m^2 from 1 until 39 d of age. This study found that increased stocking density had a negative effect on some aspects of bone quality (tibia curvature and shear strength) and that the birds tibias were shorter at high density, possibly due to increased curvature.

Ventura et al (2010) showed that broilers kept at high densities had more severe footpad ($P < 0.0001$) and hock lesions ($P < 0.0001$) than those kept at lower densities, and these authors concluded, that increased stocking density had a negative effect on broiler footpad health.

High litter moisture content exacerbates the incidence of contact dermatitis (Dozier et al., 2006). Meluzzi et al (2008a) studied the effects of low stocking denity (11 birds /m^2 and 14 birds /m^2) and noted that lower stocking densities, and attention to litter quality by use of a greater amount of litter material, significantly reduced the occurrence of FPD.

These multiple findings and studies indicate that management factors, in addition to stocking density, during the rearing period of the birds can critically affect the health of the birds. In a study carried out by Arnould & Faure (2003) the distributions of two groups of chickens reared at a density of 2 chickens/m^2 and at 15 chickens/m^2 were compared. The rearing density had a clear and significant influence on the occurrence of foot pad and hock dermatitis.

Will birds 'work' to move to areas of low density?

Buijs et al. (2011a) showed that broilers will 'work' to move to an area with decreased stocking density. In these studies, the birds were separated from the lower density area by a barrier, and birds chose to cross the barrier to move into the lower stocked area - preferring a lower stocking density than the commercially used 42 kg/m2. This experiment showed that broilers were willing to work for increased floor space allowance; the lower the stocking density on one side of the pen, the more birds moved to this side.

Management factors become more critical at high stocking density

Jones and co authors (2005) from Oxford University carried out a large commercial-scale experiment in which 10 major broiler producer companies stocked whole houses of birds at 30, 34, 38, 42, and 46 kg/m^2 . The study involved a total of 2.7 million birds in 114 houses on commercial farms and a wide range of environmental and bird variables were measured. The summary conclusions of this stutdy stated that;

"Much of the variation in broiler health and welfare was associated with the percentage of time a company could maintain house temperature and relative humidity (RH) within limits recommended. Controlling the environment, particularly temperature, humidity, and air and litter quality, is crucial to broiler chicken welfare. This does not mean that stocking density is unimportant, but lowering stocking density on its own, without regard to the environment the birds experience, is not sufficient. Genuine improvements in bird welfare will come from setting standards that combine stocking density, safeguards on the environment, and the genetic makeup of the birds."

An interpretation of this would be – if conditions can be assured to be good, then it may be possible to keep broilers at higher stocking densities, but if it cannot be assured that good environmental and management conditions can be provided at all times, then stocking density will become important. This study rightly identifies that it is the quality of environment and management which is of critical importance in maintaining the welfare of the birds – and for this reason – if a country or system decides to permit high stocking densities, it must be VERY confident that in all farms, and for all of the time, the factors of management and house quality can be maintained to the highest levels. In the reality of day to day farming, this seems unlikely to be achieved – and when management of housing factors fail, then, at high stocking density, it is lkely, or even inevitable, that bird welfare will suffer.

De Jonge & Van Trijp (2013) in a study on consumer perceptions of animal welfare identified that stocking density was considered by consumers as an important predictor of the perceived animal friendliness of livestock production systems. In this study, they identified that a stocking density of over 12 birds/m^2, was considered as a threshold for consumer perception.

Conclusions

- High stocking densities have a very clear negative effect on bird growth. This supports the view that, at high stocking densities of above 15 birds/m^2 at slaughter age (if a bird weighs 2 kg at this age, this equates to 30kgm^2 at 0.067 m^2 per bird), a very 'basic element' of the concept of farm animal production starts to be compromised – i.e. growth is suppressed.

- As stocking density increases, the potential for severe gait impairment increases. Studies on commercial farms have shown a decrease in growth rate and walking ability as stocking density increased, and increased disturbance of rest, all indicative of decreased welfare.

- Air quality (temperature, humidity, dust and ammonia, CO_2, CO levels) in a broiler house is determined by a complex interaction between factors, including ventilation, stocking rate, litter quality, age and health status of the birds. Higher stocking densities put greater stress on the management of air quality – and poor management of air quality has increasing potential for negative effects on the welfare of birds kept as they are kept at increasingly high stocking density.

- The risk of heat stress in broilers increases very drammatically with increased stocking density as heat production increases and as space between birds (and hence their ability to lose heat) decreases.

- Good litter quality is essential for broiler health and welfare. Failure to maintain good litter quality is common, and maintenance of good litter becomes increasingly hard as stocking density increases. Poor litter quality has very clear implications for bird health and welfare, and this is increasingly the case as stocking density increases.

- At the root of commercial broiler production has been a move toward higher productivity at a younger age. Some broiler birds can now reach 2kg weight by 33 days and this rate of growth is entirely dependent upon the very highest standards of technical capacity, management and farm environment.

- The effects of increasing stocking density become more apparent and severe at stocking above 15 birds/m^2 at slaughter age. If a bird weighs 2 kg at this age, this equates to 30kgm^2 or 0.067 m^2 per bird.

- Turkeys are kept at very high relative stocking densities – and the intention to permit them to be kept at up to 60 in the Austrian 'All in One' standards will represent a very high stocking density. At these densities their behaviours are compromised by space restrictions and they suffer feather and joint disorders and may also suffer difficluties in thermoregulation due to physical obstruction by other birds. It is interesting to note that the RSPCA standard limits stocking density for turkeys to a maximum of 25 kgm^2 (whilst the Austrian 'All in One' standards will permit up to 60 kgm^2 – which is 2.4 times this or 240% of the RSPCA determined upper limit).

- The key pressure to increase stocking density is economic – the wish to produce more income per unit area of space. As stocking density increases beyond a certain point – increases in economic gain are almost certainly at a direct cost in the available space for birds to express a range of behaviours withour obstruction, and the physical mass and presence of the birds starts to interfere with the litter quality, air quality, the ability of birds to regulate and lose heat, and the mobility of the birds. The sum of this is poor welfare.

- The choice of just three measures (Mortality, DOA and Pododermatis) in the “all in one” programme on which to base a stocking density adjustment is not a strong decision. Other countries have elected to make a much more rigorous and wide-ranging range of measures in their assessments.

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