Broiler production and welfare in the county of Södermanland

Produktion och välfärd hos slaktkyckling i Södermanland

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1. Abstract
80 million broilers are reared in Sweden each year and broiler welfare is a worldwide issue. The main aim of this study was to investigate and describe a part of the Swedish broiler production and to analyze the relevant literature to find strengths, weaknesses, identify riskfactors and propose possible solutions. This was done by an extensive review of literature and by on-farm observations made on official animal welfare controls conducted by the County Administrative Board. The main results are that fast-growing hybrids are prone to lameness, disease and unnatural behaviour and the most common remarks on farms from the official animal welfare controls was covering of daylight inlets and poor litter quality. The most common reason for condemnation in Sweden was skin disorders (42 %) and in the county of Södermanland 26 % and 17 % of the foot score sessions resulted in remarks on a high and low level respectively. Conclusions are that the producers are the key factors for a successful production, which is vulnerable and that high biosecurity also is a strength. Risk factors for animal welfare problems include the use of fast growing hybrids. The possible solutions to this are to grant the producer more influence over the production and to switch to slow-growing hybrids. A number of risk factors covering the period from introduction to slaughter were identified.

2. Introduction
Poultry meat is a popular food in Sweden and the welfare of broilers has been given attention in the media and parliament during the last years (Sveriges Riksdag, 2008; Svenska Dagbladet a-d, 2008; Esping & Esping, 2010; Dagens Nyheter, 2011; Djurens Rätt, 2012 a).

2.1. Rearing in Sweden

About 80 million broilers are reared by 115 producers located in the middle and south of Sweden each year (The Swedish Board of Agriculture, 2011; The Swedish Poultry Meat Association c, 2011; d 2011; Secher. E., The Swedish Poultry Meat Association, personal contact, November 6th 2012). Of the involved actors in the chain of broiler production 99 % are members of the trade organization for poultry meat production, The Swedish Poultry Meat Association (Gustavsson, P., The Swedish Poultry Meat Association, personal contact, October 4th, 2012). This means that almost every producer in Sweden rearing broilers is connected to The Swedish Poultry Meat Association's animal welfare programme allowing them to exceed the maximum stocking density stated in the legislation of 20 kg/m^2 to 36 kg/m^2 (SJVFS 2010:15). In practice this means that 96 % of the Swedish broilers are being reared at a stocking density of 36 kg/m^2 (The Swedish Poultry Meat Association, 2010).

In general the broiler production systems around the world are intense with a high uniformity. The buildings holding the chickens look alike, with the heating and ventilation systems varying with climate (SCAHAW, 2000; EFSA, 2012). Conventional broilers never go outside but they have windows providing them with daylight, stated in Swedish legislation (SJVFS 2010:15). Even though Swedish regulation goes further than the regulations set by the European Union (Council directive 2007/43/EC; SJVFS 2010:15), giving a potential for a higher welfare of broilers produced in Sweden, a large part of the consumed poultry meat is imported. The consequence of this is that more than a third of the meat, consumed in Sweden, is produced under rearing conditions that would not be legal in Sweden. There is an ongoing debate by Swedish animal welfare and animal rights organizations questioning if even the Swedish production is acceptable from a consumers ethical and moral point of view (Djurens Rätt, 2012; Djurskyddet Sverige, 2012).

In November 2012 there were 115 broiler producers, 17 broiler breeder producers, five hatcheries, eight slaughter plants and four feed manufacturers which all are located in the middle to southern Sweden, clustered around the slaughter plants (Secher. E, The Swedish Poultry Meat Association, personal contact, November 6th, 2012). The buildings are divided into sections, where all the birds reared together in the same section is defined as one flock. The number of buildings and sections vary between producers and farms and the number of birds in a section varies with the size of the section. If the goal finishing weight is 1.6 kg or 2.3 kg the number of animals allowed per square meter are 21.8 or 15.5 animals, respectively, with an allowed stocking density of 36 kg/m^2. Producers rear approximately seven batches during a year, a batch corresponds to all the birds reared on the farm during a rearing period, which results in a total of 595 000 produced broilers per year by the average producer (The Swedish Poultry Meat Association d, 2011).

2.2 Performance and welfare

During optimal conditions it takes approximately 30 days for the commercial broiler hybrids used in Sweden to reach a live weight of 1.6 kg (Aviagen, 2012; Cobb-vantress, 2012), hybrids used are Cobb 500 and Ross 308 (personal contacts, September, 2012; Gustavsson, P., The Swedish Poultry Meat Association, personal contact, October 31st, 2012). Swedish broilers are slaughtered at weight of 1.6 – 2.3 kg and at an age of 32-40 days, with the lighter ones being sold as whole birds and the heavier ones sold as meat cuts (personal contacts, September, 2012; Gustavsson, P., The Swedish Poultry Meat Association, personal contact, October 29th, 2012). The feed conversion rate during optimal conditions is high, 1.4 – 1.5 kg feed is required for 1 kg live weight gain, which results in a total feed consumption of ca 2.2-2.4 kg per broiler weighing 1.6 kg (Aviagen, 2012; Cobb-vantress, 2012).

Over the last 12 years broiler and broiler breeder welfare have been extensively reviewed (SCAHAW, 2000; Weeks & Butterworth, 2004; Duncan & Hawkins, 2010; de Jong et al. 2012). The life of a broiler is about four to six weeks long, spent with 20 – 40 000 other chickens in barren environment with little possibility to perform natural and species-specific behaviours, and with extreme growth rate sometimes leading to leg problems and metabolic disorders (EFSA, 2012), but free from predators, hunger, competition, disease and other dangers that would lurk in the wild.

The interest for broiler production began with the County Administration of Södermanland's wish to get a mapping of the riskfactors of today's production, they had also observed a lot of broilers falling of the conveyer belt at the mechanical catching of broilers. Furthermore the reports on Swedish broiler welfare are a few years old why an update is needed. The Swedish legislation is also stricter than the EU legislation, but does this simply translate to better welfare?

2.3. Aim

The aim of the study was to investigate and describe the chain of broiler production in the county of Södermanland, south east Sweden, to investigate and analyze the relevant literature available today and to get an overview of the whole line of production, from introduction of day-old chicks to slaughter of 32-40 day old birds. What are the strengths and weaknesses and are there any solutions available today? Can any risk factors be identified? How is the introduction of day-old chicks carried out? How common is lameness? Is the loading of birds prior to transport a risk factor?

3. Materials and methods

3.1. Data collection and literature

Relevant scientific literature was reviewed. Initially literature was found in the report "Scientific report updating the EFSA opinions on the welfare of broilers and broiler breeders" by de Jong et al. from 2012 and the book "Measuring and auditing broiler welfare" by Weeks & Butterwort from 2004. Literature was then searched in the databases Scopus, Web of Knowledge and the Swedish University of Agricultural Sciences own database Primo with no limit on publication date, but with most attention given to newer literature. Keywords used were e.g. broiler*, chick* or poultry in combination with one or more of the following e.g. air, ascites, ammonia, behaviour, breeder, campylobacts, catching, coccidiosis, coliform cellulitis, condemnation, deep pectoral myopathy, feed, femoral head necrosis, foot pad dermatitis, growth, handling, harvest, health, insertion, lameness, light, loading, mortality, organic, rearing, salmonella, slaughter, stocking density, stress, sudden death syndrome, Sweden, Swedish, temperature, transport, ventilation and welfare.

Data was collected during the autumn 2012, during official controls conducted by The County Administration of Södermanland and The Swedish Poultry Meat Association (Animal welfare programme), extracted from reports from slaughter plant veterinarians and from producer records. The order of the controls was primarily determined by the slaughter schedule, i.e. if the farm was empty or not, and to some extent by where the farms were geographically located. Official controls were attempted to be conducted unannounced, but if the producer did not have time the first occasion a new visit was scheduled, 5 of 11 controls were unannounced. Time between announcement and visit varied from 18-20 h to a few weeks before the visit.

During a visit all the sections were walked through together with the producer or the person responsible for the birds, but if this was not possible at least half of the sections were walked through and the rest was observed by looking through a window. At one farm only 25 % of the sections were walked through and the rest of the sections were not observed since the birds in these sections had been sent to slaughter. At each walkthrough a few animals were lifted and feet and body condition was checked by visually inspecting and palpating the feet and body of the animal. If a bird in need of culling was found the producer or responsible person was asked to cull the bird to see that the euthanizing was performed accurately, birds found in need of culling were almost always culled during the visits. The litter was checked by looking at it, feeling if it was wet, sticky and/or sagged by walking on it and scraping the litter with the foot, and if the air was unpleasant to breathe ammonia levels were measured with a Dräger CMS and Dräger CMS chip (Dräger Safety Sverige AB). All producers had alarm-devices set to want if CO_2 levels were above 3000 ppm, and if the temperature was too high why these parameters were not measured. The amount of dark hours per day and if windows were covered or not was also controlled, as well as feeding routines. When controls were finished a control check list stating if the legislation was followed or not, from the County Administrative Boards was filled out together with the producer (the check list for broilers "Slaktkyckling" is available in Swedish and for download at http://www.jordbruksverket.se/amnesomraden/tillsyn/instruktionertillkontrollanter/djurskydd/vagledningarochchecklistor.4.67e843d911ff9f551db80005152.html).

3.2. Interviews

At the same time as reviewing the animal welfare inspection check list 10 broiler producers were interviewed. Interviews were conducted to complement the information gathered through inspections. Questions asked were:

- Is any farm-produced feed used?
- How high is the total mortality and how high is the first week mortality?
- How old are the birds?
- What is the expected slaughter weight?
- When is the last culling prior to loading carried out?
- Does the producer have other businesses except broiler production? If so, what kind of businesses and are they located on the same farm as the broiler production?
- Do the employees managing the animals have any other work assignments than the birds?

If any question was forgotten during the interview it was later asked by telephone or email. Additional information was also provided by telephone or email, the additional information being number of birds culled and found dead in each section, mean weight and number of animals in each section at the day of slaughter and if The Swedish Poultry Meat Association had carried out the follow-ups stated in the animal welfare programme due to high foot scores.

3.3. Introduction of day-old chicks

One farm was visited when day-old chicks was being introduced. Introduction into two different sections were observed and documented with notes and photographs. Parameters registered were:

- Light level
- Temperature
- Number of chicks inserted
- Amount of time needed to complete the introduction and number of people carrying out the introduction
- Area accessible to the chicks
- How chicks were moved from the containers to the section floor
- Risk for injuries
- The behaviour of the chicks

3.4. Data collection on catching of broilers

The loading of four units was inspected and followed to slaughter, whereof two visits were announced and two visits were unannounced. The study was performed on 30-32 days old Ross 308 broilers, 15 broilers from each unit was used, resulting in a total of 60 animals where 40 belonged to the control group and the remaining 20 was chosen to investigate effect of risk factors during catching and loading. The selection of units visited was based on when the loading was going to occur to fit in with The County Administration's schedule. A protocol for investigating the loading of birds prior to slaughter was formed in collaboration with an animal welfare officer at The County Administration of Södermanland and included:

- Sound level
- Conveyer belt speed
- Drop height of the conveyer belt
- Who was carrying out the catching

3.4.1. Catching machine

The catching and loading was observed. Catching was performed using a machine that caught the birds and via a conveyer belt loaded them into plastic containers. Two Chicken Cat catching machines were used, in 2012 they were altered to have side-barriers at the end of the conveyer belt, preventing the birds from falling off, and a scale that lowered the speed of the conveyer belt. The conveyer belt had a scale at the front edge. When the loaded weight of the animals was near the maximum weight the speed of the conveyer belt was decreased and when the containers were filled with the maximum weight the conveyer belt stopped automatically. The scale was set to 72 kg by the loading personnel, aiming for 42 birds per container and the speed was lowered at 70 kg, a red light on the operating panel was lit when loaded weight exceeded 72 kg. Surplus animals was either moved to the next container or put back in the front of the conveyer belt. The speed of the conveyer belt was 1.2-1.5 m/s. One person operated the arm of the catching machine where the birds were caught by rubber fingers (see Figure 3 and 4), and one or two persons operated the conveyer belt that dropped birds into the containers (see Figure 5 and 6).

3.4.2. Clinical examination

During on-farm loading for transport to slaughter a clinical examination was conducted on 10 birds just prior to loading (control) + 5 birds jumping off or falling down from the containers or the conveyer belt (risk of injury). An assistant held the birds while the examiner (trained by an official slaughter plant veterinarian) carried out the examination. First the bird was held with its chest and feet towards the examiner and the feet and chest was visually inspected and palpated to assess feet and breast burns, the legs were the gently bent to check for fractures and normal mobility. The birds were then held horizontal with the rear towards the examiner; the wings were gently pulled out simultaneously to check for normal retraction and fractures. Birds were marked on their back with a crayon meant for marking animals (Märkstift, Granngården), blue marked control birds and red marked birds that jumped or fell off the containers. Should a bird examined prior to loading fall or jump off the containers it was moved to the red category. The containers holding the examined birds were marked with masking tape.

At the slaughter plant the birds were moved from the transport vehicle to the lairage section were the containers were placed in tight rows, two containers on top of each other. The containers were then moved by forklift to the start of the slaughter line where the individual containers were transferred to a CO_2 gas stunning tunnel on a conveyer belt. The focal birds, now dead, were clinically examined again after exit from the gas tunnel, but prior to being shackled, by the same examiner with exception for the first occasion when the official veterinarian responsible for food safety on duty also carried out examinations. Birds were held upside-down in their legs as bruises and wing-fractures were checked and then on their back to check the legs for normal mobility and fractures. The birds were then shackled by the slaughter plant personnel.

3.4.3. Critical control points

Information was gathered from scientific literature, interviews with producers, personnel at The County Administration of Södermanland, official veterinarians at a slaughter plant and own observations. Critical control points were identified from literature as when injuries were found when this occur, from interviews when producers, the personnel at The County Administration of Södermanland and the official veterinarian found that this might be a problem or a risk as well as own observations.

4. Results

4.1. Literature review

4.1.1. Legislation

4.1.1.1. EU legislation

Only the main differences that separate EU regulations regarding broiler production (Regulation (EC) No 1831/2003 of the European parliament and of the Council of 22 September 2003 on additives for use in animal nutrition; Council directive 2007/43/EC of 28 June 2007 laying down minimum rules for the protection of chickens kept for meat production) from Swedish regulations will be described. Overall regulations set by EU are more general than Swedish regulations, e.g. it is stated in EU regulations that the noise level must be minimized and in Swedish regulations that noise levels may only occasionally exceed 65 dB.

Directive (EC) No 2007/43 states that the maximum stocking density is 33 kg/m^2, but if certain additional requirements are fulfilled the maximum stocking density is 42 kg/m^2. There are no regulations for maximum levels of air pollutants or noise if the stocking density is up to 33 kg/m^2, however if the stocking density exceeds this the maximum level of ammonia is 20 ppm and 3 000 ppm for carbon dioxide. There is no requirement for daylight inlets and there are no regulations regarding broiler catching. Beak trimming may be used/applied in cases of feather pecking and cannibalism where other measures to prevent this do not work, in this case it shall be carried out before chickens reach the age of 10 days.

Regulation (EC) No 1831/2003 states that antibiotics as growth promoters are not allowed to be used in feed, however antibiotics are used in European poultry production, but how much is used for broilers cannot be specified since the category “poultry” includes both broiler, laying hens and turkeys (European Medicines Agency, 2012).

4.1.1.2. Swedish legislation

Legislation applying to Swedish broiler production is found in the Swedish Animal Welfare Act (1988:534), The Swedish Animal Welfare Ordinance (1988:539) and The Board of Agriculture's regulations and guidelines on animal management in agriculture (SJV FS2010:15, L100; SJVFS 2011:5, L 100:2), The Swedish Board of Agriculture's regulations and guidelines on transport of live animals (SJVFS 2008:69, L5) and The Swedish Board of Agriculture's regulations and guidelines on slaughter or killing of animals (SJVFS 2012:27) and will be generally described below.

The Swedish Animal Welfare Act states that animals shall be treated well and be protected from unnecessary suffering and disease and the environment they are kept in should promote health and permit natural behavior. It is prohibited to subject animals to surgical procedures or injections except when they are necessary for veterinary medical reasons, beak trimming is therefore not allowed, and it is prohibited to use hormones other than for treatment of disease.

The Swedish Animal Welfare Ordinance states that objects and substances that may harm the animals shall be kept out of reach of the animals and that animals shall be kept satisfyingly clean.

SJV FS2010:15, L100, states that broiler buildings must have inlets for daylight, except for buildings in use before 1994, broilers may only be temporarily exposed to noise exceeding 65 dB and air pollutions exceeding 10 ppm for ammonia and 3 000 ppm for carbon dioxide. Broiler buildings with mechanical ventilation must be equipped with

emergency ventilation and buildings holding more than 2000 broilers must have a back-up generator and be equipped with alarm devices that warn for too high or low temperatures and power failure. Maximum stocking density is 20 kg/m^2, unless producers are connected to a control programme. If so maximum stocking density is 36 kg/m^2 and 25 animals/m^2. Broilers must be inspected twice a day and a broiler with difficulties walking or other signs of injury or disease should be euthanized. Broilers reared indoors should be kept on litter and water spillage should be kept to a minimum. During the rearing period, except for the first week and the last three days, broilers must have a dark period of at least six hours and at least four of these hours must be uninterrupted. Broiler must have ad libitum access to water and feed or be meal fed with appropriate intervals, withdrawal of feed may not occur earlier than 12 hours before estimated time of slaughter. SJVFS 2011:5, L 100:2, states that conveyer belts used for broiler catching must not be operated at a speed or be used in other ways that may cause injuries or suffering to the animals and those injured or weak animals that are found shall immediately be separated and euthanized if welfare cannot be maintained.

SJVFS 2008:69, L5, states that animals getting sick or injured during the transport shall be prioritized and given veterinarian care or be euthanized and all of the cargo area should be easily accessible for inspection of the animals. All broilers that are transported must be fit for transport, sick or injured animals must not be transported, and maximum transport time is eight h. Exceptions may be made when the transport time to the nearest slaughter plant is more than eight hours, in which case the transport time may occasionally be extended to up to 11 hours and when broilers are transported during the dark hours where the maximum transport time to the nearest slaughter plant may be extended to up to 12 hours. For broilers, the requirement for easily accessible cargo areas is seen as fulfilled if there are temperature monitors in the cargo area. Stocking density in the transport containers should be adjusted according to season and outside temperature.

SJVFS 2012:27 states it is allowed to shackle poultry with a weight of up to 20 kg.

4.1.2. Animal welfare programme

The Swedish Board of Agriculture has officially approved an animal welfare programme conducted by The Swedish Poultry Meat Association. On farm inspections are carried out every other year (Waldenstedt, L, The Swedish Poultry Meat Association, personal contact, October 23rd, 2012). 99 % of the involved actors in the chain of broiler production are members of The Swedish Poultry Meat Association and are therefore connected to the animal welfare programme which includes the foot health programme measuring the prevalence of foot pad dermatitis. The animal welfare programme allows the maximum stocking density to be increased from 20 kg/m^2 to 36 kg/m^2 depending on the total score, for a particular producer.

The animal welfare programme consists of 31 control points evaluating buildings, ventilation, feed, heating, lighting, biosecurity, alarm, back-up generator, electrical equipment, animal management, litter, documentation and slaughter quality. Each point gets a score, from 1-4, that is multiplied with a factor, from 1-11, that results in the total score for each point and depending on the total score of all points the maximum allowed stocking density is set. The programme also includes guidelines for catching, loading, transport and slaughter of broilers, e.g. feed must be available until at least six hours before catching and water until 30 minutes before catching (The Swedish Poultry Meat Association 2011 e).

Foot health examinations are conducted, by examining 100 feet from each flock, at the slaughter plant by the official veterinarian employed by The Swedish National Food

Agency. These figures are then reported to the producer, the slaughter plant and The Swedish Poultry Meat Association. The foot scores are not routinely reported to the County Administrative Boards, but can be requested by the County Administrative Boards from the Swedish poultry meat organization. However, the producers are often very cooperative in reporting foot scores to the County Administrative Boards when asked (County administrative of Södermanland, personal contact, October 17th, 2012). Foot scores are recorded once from all flocks in a batch, since factors affecting foot health may vary a lot between flocks and sections. However, sometimes flocks are transported in the same transport vehicle why a single scoring may include feet from two flocks. The feet are allocated to three classes; 0=no remark, 1=mild changes and 2=severe changes. Class 0 scores are multiplied with 0, class 1 with 0.5 and class 2 with 2, resulting in a total score of 200 points and with the greatest emphasis put on the most damaged feet. A total score below 40 results in no remark, above 40 as a remark on a low level and above 80 as a remark on a high level. The remarks are then followed up, in case of remark on a low level the stocking density is lowered with 1 kg/m^2 at the second occasion, 2 kg/m^2 at the third occasion and so on, in case of remark on a high level the stocking density is decreased with 2 kg/m^2 at the first occasion, with 3 kg/m^2 at the second occasion and so on. The stocking density can be decreased to 20kg/m^2 and when foot health is improved the allowed stocking density is gradually increased. When foot scores are available from the batch just slaughtered the next batch is already in the incubators at the hatchery, therefore decreases in stocking density will apply to the second next batch after the one that got the high scores (The Swedish Poultry Meat Association 2011 e).

A proposal for an updated animal welfare programme is currently being developed (Waldenstedt, L, The Swedish Poultry Meat Association, personal contact October 23rd, 2012).

4.1.3. Production figures

Approximately 79.4 million broilers are slaughtered in Sweden and the yearly consumption of poultry is 18.6 kg per person. (The Swedish Board of Agriculture, 2011; The Swedish Poultry Meat Association a, 2011; b, 2011). Broilers slaughtered include 1.5 % condemned broilers, which corresponds to 1.2 million animals or 2 000 ton. During rearing mortality is 3 % (Waldenstedt, L., The Swedish Poultry Meat Association, personal contact, November 14th, 2012) corresponding to 2.5 million broilers resulting in a total of 81.9 million broilers each year.

A total of 176 700 ton poultry was consumed in 2011 of which 67 800 ton (39 %), was imported (The Swedish Poultry Meat Association a, 2011; b, 2011). In total 121 000 ton poultry was produced (The Swedish Poultry Meat Association a, 2011). The consumption of poultry is and has been increasing, in 2010 the total consumption was 171 200 ton which corresponds to a total increase of 2.5 % during 2011 (The Swedish Poultry Meat Association a, 2011; b, 2011).

Regarding the export from Sweden there are no available numbers from 2011, in 2010 the figure was 13.9 ton, but by subtracting the consumption (176 700) from the production and import the figure 12.1 ton is obtained ((121 000 + 67 800) - 176 700 = 12.1) (The Swedish Poultry Meat Association a, 2011) which at least can give a rough estimation.

There are 5 companies slaughtering 99 % of the Swedish broilers, with the biggest ones slaughtering 38 million and 19+11 million (two separate slaughter plant facilities) per year and the smallest ones slaughtering 1.1 million and 0.6 million per year. The fifth slaughter plant is somewhere in the middle, but no more precise figure was available

(Guldfågeln AB, 2012; Knäreds Kyckling AB, 2012; Lantmännen Kronfågel AB, 2012; Ingemarsson, M, Bjärefågel i Torekow AB, personal contact, October 26th, 2012; Gustavsson, P., The Swedish Poultry Meat Association, personal contact, October 4th, 2012). All companies only use the hybrid Ross 308, except for the second largest one which mainly uses Cobb 500 (personal contacts, September, 2012; Gustavsson, P., The Swedish Poultry Meat Association, personal contact, October 31st, 2012). Only at the largest birds are stunned in the transport containers, with gas stunning followed by electrical stunning (Nederman, M., Lantmännen Kronfågel AB, personal contact, September 7th, 2012). Remaining slaughter companies shackle the birds prior to electrical stunning, this corresponds to 52 % of the slaughtered birds (personal contacts, September, 2012; Gustavsson, P., The Swedish Poultry Meat Association, personal contact, October 31st, 2012).

4.1.4. Behavioural restrictions

Semi-wild red junglefowl (*Gallus gallus*) spend 60 % of their waken time ground pecking and 34 % ground scratching (Collias & Collias, 1967) while commercial broilers only spend 5-6 % of their time eating (Weeks et al. 2000). It has also been shown that fast-growing meat type broilers are less active than slow-growing lighter broilers, slow-growing birds covered a daily distance of 1 230 m while fast-growing ones only covered 10 % of that distance, 125 m (Bosco et al. 2010). Lameness is affecting activity, in fact lame broilers lie down for 86 % of their time whereas broilers that are not lame lie down for 76 % of their time (Weeks et al. 2000). The inactivity itself even further impairs walking ability as it worsens leg disorders (Mench, 2004; Stojcic & Bessei, 2009). Irrespective of lameness the broilers of today spend much more time inactive than their wild ancestors. In 2012 EFSA, the European Food Safety Authority, concluded that "High stocking densities disturb locomotor behaviour and rest, both of which have an influence on leg health in broilers although the nature of this impact is not clear, selection for increased growth impedes the activity level of broilers, enrichment strategies may alleviate behavioural restriction of broilers by increasing locomotion and preventing disturbance of rest" (de Jong et al. 2012). To increase activity enrichment such as scattering feed on the ground or placing straw bales in the section can be used as they increase walking, running and foraging (Kells et al. 2001; Jordan et al. 2011). Spin feeders that distribute feed on the ground over a circular area are currently used when feeding broiler pullets in Sweden (The Swedish Board of Agriculture, 2012). The weight of a broiler is physically limiting its ability to be active and most likely its ability to behave natural (Bokkers et al. 2007) and the high live weight and fast growth rate are important causes of lameness (Kestin et al. 2001). One way of slowing down growth rate is to provide longer periods of darkness and thus shorter day length (Classen et al. 1991).

Dust-bathing is a natural behaviour that is limited by the degree of lameness as broilers with tibial dyschondroplasia dust-bathe less than birds not diagnosed with this disorder (Vestergaard & Sanotra, 1999). Fear can also limit the behaviour but regular handling and visual contact are effective ways to reduce fear of humans (Jones, 1996) and fear of humans can affect performance in terms of decreased feed conversion efficiency (Hemsworth et al. 1994) meaning that growth will be impeded.

Higher growth rate, weight gain and body weight increase the risk of poor welfare in broilers, e.g. increased lameness and foot pad dermatitis, this is even so for slow-growing strains reared under organic conditions (Kestin et al. 2001; Keppler et al. 2010). The distance walked by broilers is affected both by motivation, the longer the feed deprivation the longer distances walked, and by physical ability with lighter birds being

less hampered by their weight, management factors that reduce leg problems are important and are likely to reduce growth rate and production (Bokkers et al, 2007). Increasing stocking densities, from 6-23 kg, has been shown to strongly influence leg strength negatively (Buijs et al. 2009).

4.1.5. Health problems

Meticulous culling of sick or injured broilers is the main way to alleviate suffering in individual birds, as sick or injured broilers are not given any veterinary treatment. Mortality figures can be divided into culled animals and animals that are found dead. If almost no broilers are found dead welfare is likely to be high irrespective of high or low mortality, if some broilers are found dead and some culled the welfare is likely to be poor or acceptable in the case of high mortality and acceptable in the case of low mortality, if on the other hand almost all deceased and injured broilers are found dead the welfare is likely to be poor in the case of high mortality and acceptable in the case of low mortality (Butterworth, 2004). One of the main goals with The Swedish Poultry Meat Association's animal welfare programme is to prevent disease and improve the broiler health.

Broilers are kept in large flocks and this may increase the infection pressure in the section since diseases have more individuals to afflict (Vågsholm, 2003). Furthermore, there is a risk of circulation of contagious diseases between individuals where infected individuals recover and are then re-infected (Herlin et al. 2007).

First week mortality depends on multiple factors and unhealthy chicks that are weak, sick, malformed, underweight, dehydrated or stressed are culled since they will not perform according to their capacity (Yassin et al. 2009). Some of the factors affecting first week mortality is breeder age, middle aged breeders (38-44 weeks old) gives the most vital progeny, egg storage time at the hatchery, strain and the feed company providing the breeders with feed (Yassin et al. 2009).

4.1.5.1. Lameness

Lameness is considered to be one of the most important welfare problems in broilers causing pain, discomfort and behavioural restriction (EFSA, 2000; Gentle, 2011; Butterworth & Weeks, 2012; de Jong et al. 2012). Selection for fast growth of muscles and feed efficiency that results in a skeleton that cannot support the muscles are thought to be the main cause of lameness (Butterworth & Weeks, 2010; Whitehead 2010; de Jong et al. 2012). Bessei (2006) stated that "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". Lameness is caused by skeletal disorders of infectious or non-infectious origin that may overlap or influence each other (EFSA, 2000; Saif, 2008; Whitehead, 2010; Butterworth & Weeks, 2012).

Tibial dyschondroplasia (TD) is a genetic disorder that can be influenced by nutrition and prevented by supplying vitamin D (Whitehead, 2010). Tibial dyschondroplasia is the presence of abnormal cartilage in the tibiotarsal bones (Saif, 2008). Another non-infectious disorder is valgus and varus deformations of the intertarsal joint (Mench, 2004; Waldenstedt, 2007), meaning that the legs are abnormally bent inwards (valgus) or outwards (varus) (SCAHAW, 2000).

A study investigating the lameness of Swedish broilers in 2003 found that 14 % of the Ross 308 hybrids and 26 % of the Cobb 500 hybrids had a distinct defect that affected locomotion, acceleration and speed (Sanotra et al. 2003). This figure was found to be slightly lower in 2007, 12 % and 23 % respectively (Waldenstedt, 2007). Lameness increased with increasing weight and males showed more impaired locomotion than

females irrespective of weight, and prevalence of tibial dyschondroplasia was higher in Cobb 500 than in Ross 308 (Waldenstedt, 2007). The distribution of the hybrids in Sweden was 70 % Ross 308 and 30 % Cobb 500 (Waldenstedt, 2007), while numbers of today are about 60 % Ross 308 and 40 % Cobb500 (personal contacts, September, 2012; Gustavsson, P., The Swedish Poultry Meat Association, personal contact, October 31st, 2012).

4.1.5.2. Contact dermatitis: foot pad dermatitis and hock burn

In a welfare review from 2006, Bessei states that "Contact dermatitis is obviously the result of the extremely long time of sitting and poor litter quality" and Dawkins et al. (2004) concluded that management is one of the most important factors for litter quality.

Foot pad dermatitis can result in severe and painful lesions on the ventral footpads (Gentle, 2011) and the principal factor for these lesions is litter moisture content (Berg, 1998; Shepherd & Fairchild, 2010; Cengiz et al. 2011). However there are also other factors having an indirect impact on foot pad dermatitis since they affect the litter quality, the main factor is feed composition which is discussed in section 3.6. Gender and strain has an effect on prevalence; females have a higher prevalence of foot pad lesion than males and the prevalence differed between strains, why genetic selection for body weight and foot pad dermatitis can reduce the genetic predisposition to develop the disorder (Kapell et al. 2012). Humidity also affects foot pad dermatitis, incidence and severity was higher with 75 % relative humidity than with 45 % (Weaver & Meijerhof, 1991). Ventilation might not be optimally managed because of heat loss which may results in a higher humidity inside the sections (Berg, 1998). The optimal litter material in the aspect of foot pad dermatitis is frequently researched and with partly conflicting results, most recently wood shavings was found to be better than wheat straw (Nowaczewski et al, 2011) but Mendes et al. (2011) found that sawdust caused less foot pad lesion in comparison with wood shavings. However the providers of the broiler genetic material does not recommend sawdust as litter since it is dusty, moisture levels are often high, it has a disposition for mold growth and may be ingested (Aviagen, 2012; Cobb, 2012). In 1998 the most commonly used litter materials were wood shavings and straw and the prevalence of foot pad dermatitis in Sweden was 5-10 % for severe lesions and 10-35 % for mild lesions (Berg, 1998). It is stated in the animal welfare programme that broilers should be kept on wood shavings or straw (The Swedish Poultry Meat Association 2011 e).

Hock burns are skin lesions on the hock of broilers (Greene et al. 1985; Martland, 1985) and hock burn is preceded by foot pad dermatitis and followed by breast lesion both in frequency and time (Greene et al. 1985). As body weight increase so does hock burn (Haslam et al. 2007) and there is an association between hock burn and other diseases such as fever, runts and dermatitis (Hepworth et al. 2011). One of the risk factors for hock burn is body weight and this was found to be a useful indicator of flock risk for high hock burn at two weeks of age (Hepworth et al. 2010). Hock burn is also highly associated with poor litter quality (Hepworth et al. 2010) The prevalence of hock burn was 12 % in a study performed on farms in the United Kingdom (Hepworth et al. 2011).

4.1.5.3. Diseases

Diseases can be of different character, different origins and be multifactorial. For broilers some of the metabolic diseases are ascites, sudden death syndrome (SDS) and deep pectoral myopathy (DPM); infectious diseases is femoral head necrosis (FHN) and coliform cellulitis; parasitic diseases is coccidiosis. There are no figures on prevalence in Sweden available except for coccidias.

Ascites is also known as pulmonary hypertension syndrome (PHS). It is caused by

the high tissue oxygen demand of rapid growth which results in increased blood flow or cardiac output, which in turn causes pulmonary hypertension as the right ventricle and its valve is enlarged causing lung oedema and leaking and accumulation of fluids into the abdominal cavity, the heart eventually fails from the increased workload needed to pump blood through a leaking valve (Julian, 1993). The development of ascites is gradual which has high welfare implications since affected birds suffer for an extended period of time before they eventually die (Bessei, 2006). Genotype effects susceptibility (Deeb et al. 2002) and ascites seems to be a main cause for broilers dead on arrival (DOA), broiler that die during transport to slaughter, since 42 % died from heart and circulation disorders with 34% having an enlarged right ventricle (Nijdam et al. 2006).

Sudden death syndrome afflicts healthy fast-growing broilers that simply die suddenly without apparent reason (Julian, 2004; Saif, 2008), affecting mostly males (SCAHAW, 2000; Julian, 2004). Since the time from the first sign to death was only average 59 seconds (Newberry et al. 1987) the suffering is only present a short time and therefore does not pose a high risk of poor welfare.

Deep pectoral myopathy (DPM) is characterized by necrosis of the pectoral muscles (Richardson et al. 1980; Kijowski & Konstanczak, 2009) caused by ischemia, reduced blood supply causing a deficit of oxygen and nutrients, following exercise (Saif, 2008). It is positively correlated with age and body weight (Kijowski & Konstanczak, 2009) and can be induced by encouraging wing flapping (Lien et al. 2012).

Femoral head necrosis (FHN) is an infectious disorder found to be the most prevalent and widespread problem in Europe and it is mainly associated with *Staphylococcus aureus* but sometimes with *Escherichia coli*, if these bacteria are trapped in the femoral head blood vessels the infection can spread causing necrosis in the femoral head and then the bone. This condition is very painful and strongly affects walking ability and one reason for the condition may be selection for fast growth which results in decreased immune responsiveness (Whitehead, 2010).

Coliform cellulitis is an inflammation of the subcutaneous tissues caused mainly by *Escherichia coli* and characterized by exudates, an inflammatory fluid from the circulatory system, in the subcutaneous tissues (Saif, 2008). Factors predisposing broilers to coliform cellulitis are breed since fast-growing heavy strains have a higher prevalence and more severe skin scratches (Saif, 2008) and stocking density since increased stocking densities cause more skin scratches (Elfadil et al. 1996), skin scratches serves as a passage of entry for the bacteria.

Coccidiosis is caused by parasites, referred to as coccidias, belonging to the genus *Eimeria* which multiply in the intestinal tract and can cause tissue damage resulting in interrupted feeding, digestion and absorption, dehydration, blood loss and increased susceptibility to other diseases (Saif, 2008). Coccidias are present in all Swedish broiler flocks (The National Veterinary Institute (SVA), 2013). To prevent this disease broiler are routinely fed coccidiostats. However there is a public concern for coccidiostat resistance and coccidias have been found to show no, light, medium and high resistance to different coccidiostats in China (Feng et al. 2010). Coccidostats also has an antibacterial effect on the infection caused by the bacteria *Clostridium perfringens* (Waldenstedt, 2001), which can cause necrotic enteritis in young chickens characterized by a high mortality, sudden outbreak and necrosis of the small intestine (Saif, 2008).

4.1.6. Feed

There are a number of nutritional factors affecting litter quality; crude protein content, energy/protein ratio, amino acid balance, crude fat content, type of dietary electrolyte

balance is thought to affect litter quality (Veldkamp & Harn, 2009) and dietary energy, dietary protein and mineral levels affect litter moisture and quality and/or broiler water intake (Huang et al. 2011). An excess of protein causes increases in water intake, urine flow, uric acid an ammonia excretion (Ward et al, 1975). An increased water intake leads to more moisture excreted to the litter and wet litter is one of the main factors in developing foot pad dermatitis (Berg, 1998; Shepherd & Fairchild, 2010; Cengiz et al, 2011). Water spillage is also a cause of wet litter. An oversupply of nutrients also puts an extra load on the excretory system while an undersupply may cause stress and competition between individuals (Gordon et al. 2004).

4.1.7. Air

The most important function of the ventilation of a broiler building is to remove excess, heat, moisture, ammonia (NH_3) and carbon dioxide (CO_2), another important compound that need removal is dust (Aviagen 2012; Berg et al. 2012 a; Ross 2012).

Heat stress results in decreased feed intake which in turn reduces growth rate, the reason for decreasing feed intake is that it lowers the production of metabolic heat (Widowski, 2010). The older the broiler and the higher the stocking density gets the higher the risk for heat stress, this is because broiler heat production increase and space between broilers decrease (Berg et al. 2012). In case of a power failure that stops the ventilation heat stress and heat death occur within minutes in a closed broiler section (Widowski, 2010).

The number one source of moisture in broiler sections is the outside air entering the building via the ventilation. The direct effects of humidity varies with temperature, the growth is affected at temperatures above 29 °C together with a relative humidity above 70 % (Aviagen, 2012). Humidity also affects the litter quality, making it more wet with possible increases in carcass downgrades as a consequence (Aviagen, 2012) as the major factor for foot pad dermatitis is wet litter (Shepherd & Fairchild, 2011; Berg, 1998). Litter moisture and caking is reduced as ventilation levels is increased (Weaver & Meijerhof, 1991).

Ammonia is a gas that is found in all poultry houses, and the concentration of ammonia is affected by litter moisture, pH and temperature and ventilation (Aziz & Barnes, 2010). If the levels of moisture in the litter and the temperature of the litter increase so will the emission of ammonia, however the emission will be maximized at different moisture levels for different temperatures (Miles et al. 2011). A small increase in moisture at a given temperature can give rise to a large increase in emissions, at 24 °C emissions will increase 2.4 times when moisture levels increase from 20-46 % and at 35 °C the emissions will increase 6.5 times within the same moisture levels (Miles, 2012). Ammonia is irritating to the respiratory tracts and the eyes and it increases susceptibility to respiratory diseases (Aziz & Barnes, 2010), high concentrations reduce vitality, body weight, weight gain, feed conversion and immune function and increases mortality (Miles et al. 2004; Aziz & Barnes, 2010). Broilers find ammonia concentration above 10 ppm as aversive (Jones et al. 2005).

Carbon dioxide is produced and emitted by broilers and the litter and the CO_2 produced by metabolism is affected by daily weight gain, body weight and activity (Calvet et al. 2011). Levels above 3 500 ppm cause ascites and high levels are fatal (Aviagen, 2012). If the level of CO_2 increase it generally means that other gases, such as ammonia, also increases why the CO_2 levels are used to indicate overall air quality (Berg et al. 2012 a).

The sources of dust in broiler sections are mainly the birds themselves, the feed and the litter. Dust cause damage to respiratory tracts and increases the disease susceptibility (Aviagen, 2012).

4.1.8. Light

Producers sometimes ignore the legislation and cover inlets since they believe that areas on the floor with day light cause pile-ups and that the birds will inflict more injuries on each other if kept in daylight. Broilers aged between 2-6 weeks are more active when reared with outdoor access (Weeks et al. 1994). Broilers perform more active behaviours in brighter light and more inactive behaviours in dim light (Newberry, 1985) and prefer to be in bright areas when active and dim areas when inactive (Davis et al. 1999), they are also more active when reared in brighter light (Newberry et al. 1988; Kristensen et al. 2006; Blatchford et al. 2009; Blatchford et al. 2012). Contrary to a common misunderstanding, broilers do not eat more and grow faster with more light hours (Prescott et al. 2004).

Inlets for daylight are sometimes covered with little or no light entering the section throughout the rearing period, but there are also some producers providing daylight as long as it does not cause problems and disturbances among the birds (Secher, 2007). The Swedish Board of Agriculture in cooperation with the Swedish trade organization for egg production, Svenska Ägg, are currently investigating if an artificial light source can serve as a replacement for natural light (Svenska Ägg, 2012). Traditional windows might not be appropriate day light inlets. For example headlights from traffic can cause sudden light beams at night time, which might frighten the birds. Windows directed to the south can lead to areas, in the litter, of very bright light and in these areas birds might pile up and in the worst case suffocate and/or crush each other (Farmers Weekly, 2010; Bright & Johnsson, 2011). Bright light raises the activity level of the birds (Blatchford et al. 2009; Säter, 2009; RSPCA, 2011; Blatchford et al. 2012) and poorly designed inlets may cause disturbances among laying hens (Hermansson, A., Svenska Ägg, personal contact, September 27th, 2012). Daylight indirectly also makes it easier to carry out the work in the sections and to have a good supervision of the animals in lighter environments. As of today, if natural light is not present in broiler stables built after 1994 an exemption has to be applied for at The Swedish Board of Agriculture, who will approve the exemption for both broilers and laying hens until December 31st when the study is finished (Schultz, 2012).

There are some advices regarding how to design inlets for daylight made by Svenska Ägg, windows are to be placed along the whole wall with little space between and placed high to avoid inlet of direct sunlight. Gustafsson et al. (2005) also showed that shading of windows with plastic film and eaves longer than 1 m reduces light intensity. Direct sunlight can be controlled by using curtains and lux meters (Hjalmarsson, 2008). Egg and meat producers have different experiences of daylight, some feels that it works well and some state that problems can arise. It is said not to be an easy task to manage daylight inlet without problems, but it is still possible (Secher, 2007; Metlid, 2009) and an example is high placed inlets with curtains, recommended by The Swedish Poultry Meat Association “This is a good alternative that more people should consider” (Metlid, 2009 a).

It has been showed that broilers prefer different colours of light to perform different behaviours in which in turn have different effects on activity, performance, health and welfare (Prayitno et al. 1997; Rozenboim et al. 2004). To reduce activity and fearfulness at handling blue and low levels of light are used at catching and at the slaughter plant, why birds are calmer and easier to handle is not clear but it may be that the low light motivates birds to perform resting behaviour instead of alert and fear behaviors (Prescott et al. 2004).

Broilers are caught both during the dark hours and during the light hours of the day, when catching occurs during the light hours it is important to actively keep the light out of the section with curtains, to keep the animals as calm as possible.

4.1.9. Stocking density

When assessing stocking densities a number of measurements can be evaluated; space allowance per animal, kg/m^2, number of excess animals in the section (the number of extra animals above the allowed maximum stocking density), total excess animal weight, and ventilation. The result of the evaluation can vary with measurement evaluated. Broilers have been shown to experience stocking densities from 15 kg/m^2 as aversive (Buijs et al. 2011a), it has also been showed that broilers at densities higher than 12 kg/m^2 preferred areas along the wall which probably was to avoid disturbances by conspecifics (Buijs et al. 2010). Broilers are highly motivated to seek out densities below 40 kg/m^2 and to work for increased space allowance (Buijs et al, 2011). High stocking densities may affect growth rate negatively (Sekeroglu et al. 2011, Simsek et al, 2011; Zuowei et al. 2011; Benyi, 2012). When scoring welfare, the best welfare was seen at low densities, 6 kg/m_2 or 15 kg/m_2, compared to densities ranging from 23-56 kg/m_2 (Buijs et al. 2009). Space in a section with broilers aged 10 and 30 days are shown below in Figure 1-2.

The average Swedish section is 1300m^2 and with a finishing weight of 1.65 kg roughly 28 400 animals per flock are allowed. Space allowance per animal is 45.8 cm^2. When increasing the number of animals by 600 the space allowance decrease to 44.8 cm^2 showing that for the space allowance to change substantially the number of excess animals needs to be high. With 600 surplus animals there is roughly one animal too much for every 2 m^2, where it is already crowded with 22 animals per m^2. The total weight of 600 extra broilers adds up to 990 kg, almost one ton, which in turn results in 0.8 kg/m^2 excess weight per m^2. The ventilation of the sections is based on the highest number of allowed kg/m^2, which is 36 kg/m^2, and when that density is exceeded the ability to remove heat and gases is impaired why there is a risk of heat stress and gas poisoning. When taking ventilation into account it is clear that overcrowding is a welfare risk and a possible cost for the producer in terms of increased mortality.

The expected mortality is approximately 3 % which is why a surplus of day-old chicks is delivered to the producer. However, if all chicks would survive until slaughter this would result in too high stocking densities in terms of kg/m^2. Another reason for delivering plus 3 % chicks is that a surplus of chicks are hatched and delivered, in case of hatching being not as good as expected (Waldenstedt, L., The Swedish Poultry Meat Association, personal contact, November 14th, 2012).

Figure 1. Space at 10 days of age.

Figure 2. Space at 30 days of age.

4.1.10. Catching and loading

Catching is mostly carried out mechanically, with personnel operating a machine (Figure 3) that catch, transport and load the birds into plastic containers. The containers are stacked five on top of each other, depending on type and fabrication, into a module that is loaded onto a truck (Figure 6). The catching machines have long rubber fingers that catch birds (Figure 5) onto a conveyer belt that transports them to the containers (Figure 6) where they then distribute evenly over the available area, if conditions are optimal. The speed of the conveyer belt was previously approved by The Swedish Board of Agriculture to be 0.8 m/s but in 2009 the approved speed was increased to 1.2-1.5 m/s, the reason for this was that broilers landed at the front of the container and had to be manually pushed to the rear with a speed of 0.8 m/s and this was avoided at the higher speed (Swedish Board of Agriculture, 2009). If the temperature is too low or high crowding can occur to find positions with the desired temperature. The stocking density in each container depends on the size of the container, birds with a live weight below 1.6 kg must have 180-200 cm_2/kg and birds with a live weight between 1.6-3.0 kg must have 160 cm_2/kg. The containers are then moved by a forklift to the transport vehicle, a climate controlled truck. Risks for injuries are that birds can be run over by the catching machine, if birds fall of the conveyer belt, jumps out of the containers or hit each other when falling down into the containers, it is also important to carry out the catching at low levels of light since light activates birds and active birds are at a bigger risk of getting injured since they are more difficult to handle than calm and still birds. Advantages of mechanical catching is less injuries, broken wings, bruises and dead on arrival's (Gocke, 2000 referred to in Löhren, 2012 a; Remmer, 2011, referred to in Löhren, 2012 b). The disadvantage is that the rubber fingers are hard to clean and disinfect and therefore contagious diseases can be spread to other flocks/production units/farms (Löhren, 2012). Mechanical catching has also been found to result in less stressed broilers at the end of the catching process and in less wing hemorrhages than manual catching (Delezie et al. 2006).

In 2012 official veterinarians at a slaughter plant found broilers dead on arrival with injuries that indicated force, outer trauma or rough handling, they assessed that the birds had been subjected to suffering. The event and the catching company is now under prosecution (The County Administration of Södermanland, 2012).

Figure 3. Catching machine.

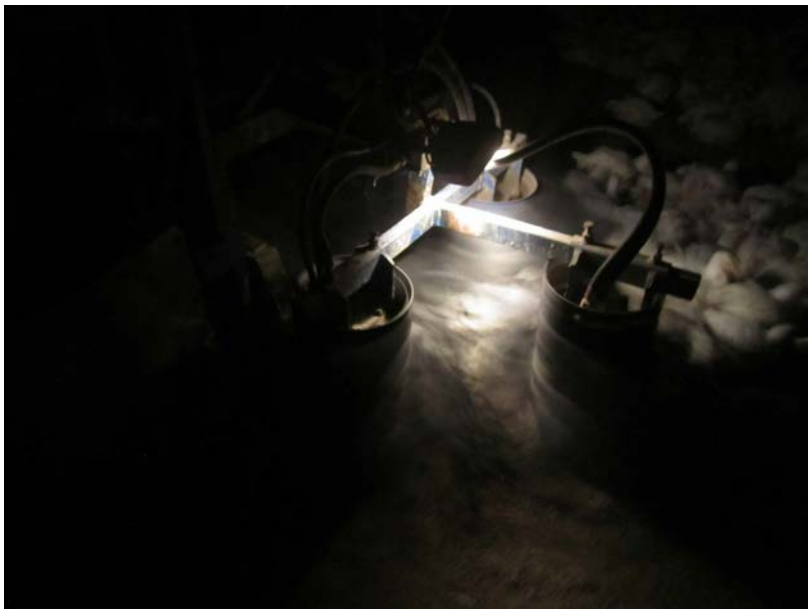

Figure 4. Rubber fingers catching broilers.

Figure 5. Broiler falling into container.

Figure 6. Containers.

4.1.11. Transport

Transport mortality is connected to all elements of rearing from insertion at farm to stunning at the slaughter plant (Chauvin et al. 2011). During transport broilers are probably more stressed than ever before because of multiple stressors from feed withdrawal, handling, catching and loading to transports. Elrom (2001) concluded that "Every additional stressor exacerbates the situation and decreases the probability of survival during and after the stress" when talking about stressors related to handling, catching, transport and slaughter. The thermal climate inside the transport is the most important factor for poor welfare and transport mortality (EFSA, 2011; Schwartzkopf-Genswein et al. 2012). However, the effect on welfare and broilers dead on arrival is multifactorial and can also depend on e.g. transport time, weight, container stocking density, health status, age, transport duration and management and/or interactions between some of these factors (Bianchi et al. 2005; Chauvin et al. 2011; Schwartzkopf-Genswein et al. 2012; Yalcin & Gulin, 2012). Studies on the effect of transport distance to the slaughter plant are contradictory, some showing that longer journeys result in higher mortality and some that they result in the same or less mortality than shorter transports (Yalcin & Gulin, 2012; see review by Schwartzkopf-Genswein et al. 2012). Thermal stress is divided into cold and heat stress and broilers positioned at different places in the transport may suffer from different ones. Broilers near air inlets may suffer from cold stress whereas broilers in poorly ventilated areas, e.g. the middle, may suffer from heat stress (Knezacek et al. 2010). The production of heat and moisture from broilers increase when the ambient temperature drop, and heat and moisture accumulated in different parts of the transport showing that ventilation to remove heat is important even in cold weather (Watts et al. 2011; Burlinguette et el, 2012). EFSA (2011) stated that birds not fit for transport are nevertheless sometimes transported and that that the stocking density should be limited in relation to thermal condition, recommending that thorough inspections are carried out to ensure that only birds fit for transport are transported.

The average number of broilers dead on arrival is 0.2 % in Sweden (Gustavsson. P, The Swedish Poultry Meat Association, personal contact, October 4th, 2012), however the daily on-farm mortality is 0.1 % indicating that if the birds were not transported half of the broilers dead on arrival would die without being transported (Gustavsson. P, The Swedish

Poultry Meat Association, personal contact, October 4th, 2012; Waldenstedt, L, October 23rd, 2012). There is no legislated limit for when the transport mortality is "too high" but when levels exceed 0.35 % an internal investigation is started at Lantmännen Kronfågel AB's slaughter plant, this only applies to birds being slaughtered at this slaughter plant (Tomasz Dzieciolowski, Lantmännen Kronfågel AB, personal contact, October 25th, 2012). In 2011 a report was made concerning a high number of broilers dead on arrival to a slaughter plant, over 10 000 dead broilers in three days. The County Administration of Södermanland carried out an inspection of the transport vehicles and found that shortcomings in the ventilation system resulted in the high number of dead broilers. The event and the transport company is under prosecution (The County Administration of Södermanland, 2011).

4.1.12. Slaughter

There are mainly two ways to stun broilers before slaughter, either with electricity or with gas with gas being the superior one in terms of bird welfare. 52 % of the birds slaughtered in Sweden are stunned with electricity and 48 % with gas (personal contacts, September, 2012; Gustavsson, P., The Swedish Poultry Meat Association, personal contact, October 31st, 2012). In 2004 the Scientific Panel on Animal Health and Welfare (EFSA) concluded that "Since welfare is poor when the shackling line and water bath electrical stunning method is used, and birds are occasionally not stunned before slaughter, the method should be replaced as soon as possible".

Electrical stunning involves shackling of the broilers prior to stunning, if birds are unloaded from containers by tipping the containers there is a concern for welfare (EFSA, 2004; European Commission, 2007). As early as in the year 2000 it was found that shackling of birds, which involves hanging upside-down with each leg inserted to v-shaped metal shackles on an over-head conveyer, is very painful (Gentle & Tilston, 2000), it is also very stressful (EFSA, 2004) and in 2009 the British Farm animal welfare council (FAWC) advocated for and end of shackling in the long run. The bird is then transferred by the shackle to an electrified water-bath were the head must enter the water for the current to go through the body, leaving the bird unconscious. The birds can be subjected to painful pre-stun shocks, e.g. if the wing touches the water-bath before the head (EFSA, 2004) and there is concern that the water-bath stunning is not efficient enough, leaving birds not fully unconscious when entering the neck-cut or scalding tank (see review by Shields & Raj, 2010). The electrical stunning can be reversible which means that the stunned bird may become conscious after a period of time.

Gas stunning avoids handling of the live bird at the slaughter plant since birds are stunned in the containers they are transported in, which is the case in Sweden. Hereby all the welfare issues connected to handling and shackling prior to stunning are removed and the birds are shackled after stunning. However there is a risk for decreased welfare during the stunning since the different gases or mixtures of gases used may be aversive to the bird, causing distress at the time of stunning, some gases can also cause convulsion (see review by Shields & Raj, 2010). The birds are either stunned by long enough exposure and high enough concentrations of the gas, controlled atmosphere stunning (CAS), making the method reversible where the birds may regain consciousness after a period of time and be shackled and neck-cut alive, or killed by long enough exposure of lethal concentrations, controlled atmosphere killing (CAK), making the method irreversible. The broilers stunned by gas in Sweden are stunned irreversibly (Tomasz Dzieciolowski, Lantmännen Kronfågel AB, personal contact, October 25th, 2012).

If the total duration of transport and lairage at the slaughter plant exceeds 12 hours birds must be provided with feed and water. This is a practical impossibility since birds are placed in stacks and tight rows awaiting slaughter, why birds are always slaughtered within 12 hours from the beginning of the loading. Should birds be left for more than 12 hours it is a violation of the slaughter regulation which could lead to prosecution. This happened, on one occasion, in 2011 when roosters were not slaughtered within 12 hours and had to wait for 21 hours in total without feed or water. If this occurs, there is a risk for impaired animal welfare. The reason for the delay was mechanical failure at the slaughter plant. This was prosecuted and the slaughter plant was sentenced to a corporate fine of 75 000 SEK (The County Administration of Södermanland, 2011 a).

4.1.12.1. Condemnations

At the four largest slaughter plants in Sweden the most common reason for condemnations during the second quarter of 2012 was skin disorders (41.9 %, equaling 123 032 broilers) of the total condemnations, the second most common reason was changes in the abdominal- and chest cavity (26.8 %, equaling 78 621 broilers) and the third most common reason was lameness (4.1 %, equaling 12 137 broilers). Each of these groups of diagnoses contains a number of different diagnoses, see Appendix (Gunilla Gålne, The Swedish National Food Agency, personal contact, November 9th, 2012).

The form for condemnation recordings used at a Swedish slaughter plant is shown below in Appendix. The form contains 8 different groups of diagnoses of which group 1-7 are reported back to the producer since the producer in both responsible and will bear the financial cost for these condemnations. Group 8, slaughter injuries, are diagnoses caused after arrival at the slaughter plant and is not shown to the producer since the producer is not responsible for these condemnations, the slaughter plant is. Hard fillets means a sub-acute degeneration of the breast muscle probably caused by strangulation of the blood supply with possible underlying factors such as heavy and fast-growing hybrids and lameness causing pressure injuries from long periods of sitting, this diagnosis may be comparable to deep pectoral myopathy (DPM). General redness of the skin means that the whole body of the bird is red, resulting from the bird being alive, although often unconscious, at scalding (The Swedish National Food Agency, personal contact, October 15th, 2012).

4.1.12.2. Condemnation diagnoses affecting the welfare of the live broiler

Inflammation of the peritoneum, lung, pericardium, air sac, kidney, yolk sac, tendon sheath, joint, epidermis and dermis, gout, ascites, some tumors, older leg injuries or fractures, sternum bursitis and hard fillets can cause suffering in live broilers through pain and/or discomfort and decreased welfare (The Swedish National Food Agency, personal contact, November 14th, 2012).

4.1.13. Broiler breeders

Grand-parent and parent stock is imported and raised in Sweden to produce the broilers (reared on commercial farms). Swedish broiler breeders are raised in free range one tier systems with access to perches and nests (The County Administration of Östergötland, 2012). Breeders are reared separated from the other sex and fed with spin feeders that disperse the feed on the floor until the age of 18-20 weeks. Then the production period of laying eggs starts and the breeders are kept in mixed-sex flocks. At least half of the floor area constitutes of litter, the other half of slats and nests. Males and females are fed separately by using raised feed throughs that that females cannot reach for the male feed

and a feed through grid that the males cannot reach through for the female feed. The growth rate needs to be limited why quantitative restrictive feeding is practiced, males can generally get a bigger portion of feed than females since their feed often contain less crude protein (Karlsson, 2010). The main issues and conclusions made by EFSA (2010) will be described, aspects not applying to Swedish production will not be described.

Feed is severely restricted during the whole rearing period to control the growth rate and body weight to avoid welfare and fertility problems mainly caused by high body weight. Severely restrictive feeding does however cause other welfare problems with hunger, competition and aggression as the main ones (EFSA, 2010). Diets with a high proportion of insoluble fiber may alleviate the sensation of hunger associated with restricted feeding during the rearing (Berg et al. 2012)

4.1.14. Organic broiler production (KRAV)

KRAV is a Swedish environmental label founded on organic values and with high requirements on animal care, health, social responsibility and climate impact (KRAV, 2012). Approximately 145 000 organic broilers are slaughtered each year, producers and the slaughter plant are located in the south of Sweden (KRAV, 2012 a). The producers rearing broilers according to KRAV's standards are not members of The Swedish Poultry Meat Association, but KRAV has its own rules regarding animal care, among others.

4.1.14.1. Rules

The rules used by KRAV are a mix of EU regulations, clarifications of Swedish legislation, IFOAM (International Federation of Organic Agriculture Movements) rules and KRAV's own rules (KRAV, 2012). The main things that separate Swedish organic broiler production from conventional broiler production which is based on Swedish legislation and The Swedish Poultry Meat Association's animal welfare program will now be outlined.

All birds must be given outdoor access in an exercise yard or pasture from the age of one month, except during the winter time when birds are allowed to be kept indoors. The outdoors must provide both feed and occupation and have vegetation during the whole period of use. It must also provide areas of shelter in the form of trees, bushes or other devices which should be designed to encourage birds to leave the stable and use the whole yard. The outdoor area should be 4 m^2 per bird, but the whole area does not need to be accessible at all times. The stable must be open during most of the day during four continuous months from May-September. Birds should be able to perform species-specific behaviours, this includes social and herd behaviour, locomotion and foraging. Birds shall have access to dust baths and perches, all animals should be able to access these at the same time and as needed. Inlets for natural light shall provide daylight in the whole stable and it should be let in through an area of at least 5 % of the floor area, but at a minimum of 3% of the floor area is an absolute minimum requirement in new constructions and reconstructions. Night rest without artificial light must last for at least eight hours. It is not allowed to treat animals routinely or preventive with medical products.

Roughage must be provided ad libitum regardless of if grass is available outdoors. All feed of agricultural origin should be KRAV-certified, however 10 % conventional feed of non-agricultural origin is allowed. Fish meal should originate from sustainable fishery but KRAV recommends the use mussel meal instead of fish meal. It is not allowed to use synthetic additives, this includes amino acids. 50% of the consumed feed should be produced on-farm and the manure should be dispersed on KRAV-certified or EU-organic soil.

The maximum number of birds allowed in one section is 4800 and the maximum allowed stable size is 1600 m^2, with the maximum allowed amount of 10 birds, or 16 birds in mobile buildings, and 20 kg per m^2.

Slaughter age must be at least 81 days for non slow-growing birds and 70 days for slow-growing birds, birds growing on average less than or 50 grams per day are defined as slow-growing. If conventional day-old chicks are bought for rearing the slaughter age must be at least 70 days. The slaughter must occur at a KRAV-certified slaughter plant and it is not allowed to slaughter broilers using shackling. Each container holding animals should be marked, animals should be able to be identified at every step of the transport and slaughter.

4.1.14.2. Rearing

The main differences between conventional and KRAV broiler production is that the birds are fed organic feed, stocking densities and birds per section are lower, birds have outdoor access, providing them with the best opportunity to behave naturally except during the winter time, all birds have access to daylight, perches and dust baths, birds are not treated with coccidiostatics, birds are slaughtered at an older age and at a higher weight and no birds are slaughtered using shackles (KRAV, 2012). However the genetic material is the same as for conventional production why health problems are the same but being influenced by age, weight and activity, and there is a problem optimizing feed, mainly in regard to protein possibly leaving organic broilers hungry. There is a public concern that birds with outdoor access will be getting infected with *Salmonella* or *Campylobacter*, however there is scientific material that partly contradicts this belief. The main risk for Swedish broilers getting infected with *Salmonella* is imported feed (Wierup, 2006) and in 2010 ten broiler units, including broiler breeders were infected with *Salmonella* (The National Veterinary Institute (SVA), 2010). In 2010 13.2% of Sweden's indoor-reared broiler batches were infected with *Campylobacter* (The National Veterinary Institute (SVA), 2010). For a review of the challenges of Swedish organic broiler production see Bassler (2008).

4.2. Broiler production figures, Södermanland autumn 2012

Facts about broiler production in the county of Södermanland, such as number of producers and broilers per section are found below in Table 1. About one tenth of the Swedish broiler producers are located in the county of Södermanland.

4.2.1. General

The interviews showed that all broilers leave the farm within approximately 1-3 days depending on how many sections and animals the producer has. At nine farms the personnel managing the broilers had only broilers as their working assignment. Sections were cleaned between each batch, disinfection was carried out between each batch at six farms with the remaining five carrying out disinfection more seldom. The last inspection round before loading was carried out between 0.5-8 hours before the start of the loading with the median being 1 hour. All farms grew their own wheat which they fed to the broilers. At two farms opened litter bales were used to activate the broilers and to dry wet litter patches by adding new litter.

Producers experienced it to be easier to maintain a good litter with heavier animals, 2.3 kg instead of 1.7 kg, since fewer animals per square meter are allowed, 15.5 and 21.8 respectively, which results in an a lower pressure put on the litter in terms of moist from excrement. They also experienced that the problems with wet litter could differ a lot even

between buildings built in the same way and next to each other with the same kind of ventilation and equipment. Most producers believed that there was an association between

Table 1. Production in the county of Södermanland.

Matter	**Figure**
Producers	10
Total number of broiler farms	11
Producers with one broiler farm	9
Producers with two broiler farms	1
Total number of sections	71
Farms were all sections were walked through	4
Total number of sections walked trough	15
Farms were half of the sections were walked through	6
Total number of sections walked trough	24
Farms were 25 % of the sections were walked through	1
Total number of sections walked trough	2
Sections per farm	8 on average, ranging from 2-12
Section area	$\bar{x}$=1300 m^2, ranging from 750-1900 m^2
Farms with an expected live weight of 1.65 kg	9
Farms with an expected live weight of 2.235 kg	2
Inserted broilers/section	$\bar{x}$=26 800, ranging from 12 500-43 300
Inserted broilers/batch	43 200-400 000
Total mortality	~3%
First-week mortality	~1%
Farms with ad libitum feeding	11
Producers with other business	10
Crop cultivation on the same farm	8
Crop cultivation on another farm	3
Farms with wood shavings as litter	10
Farms with wheat straw as litter	1

dry air and coliform cellulitis, the association being that with humid air foot scores increase and to prevent this sections were heated which resulted in dry air and this dry air resulted in a high prevalence of coliform cellulitis. Producers believed that they had to choose between high foot scores or high prevalence of coliform cellulitis.
27 % of the animal welfare programme controls conducted by The Swedish Poultry Meat Association were performed in sections without broilers, this was obtained by investigating The Swedish Poultry Meat Association's animal welfare program control protocols.

4.3.2. Shortcomings

73 % of the farms holding broilers did not let in daylight this corresponds to 69 % of the sections not providing daylight and 31 % of the sections providing daylight. 55 % of the sections without daylight were built before 1994, i.e. in buildings where daylight is not required by legislation, but for the 45 % of the buildings that were built later than this no exemptions existed. However, applications for exemptions were sent to The Swedish Board of Agriculture after the visits conducted within this study. Providing daylight or not was consistent throughout the farms with all the buildings on a farm either providing daylight or not. When daylight was provided it was so until problems with increasing

prevalence of skin scratches and disturbances arose, which was usually until the age of at least three weeks. Farms providing daylight had both poor and good litter quality. No difference in mortality could be seen between farms providing or not providing daylight. Birds suffering from lameness and in need of euthanizing were found at all farms and in all of the sections visited, regardless if the visit was announced or not. The litter was wet and/or sticky at five farms, four farms had a period of darkness shorter than 6 hours (varying between 2-5 h), farms having too little darkness had both poor and good litter quality, one farm with heavy birds provided 8 hours of darkness to decrease lameness by decreasing the growth rate. At two farms a lot of dead and sick birds were found why the culling was assessed as not sufficient, this estimation was based on the experience of the number of dead and sick birds at the other farms in the county. In at least one farm inspections of the animals inside the sections was only made once a day, ammonia levels above 10 ppm was registered at two farms and at two farms equipment posed a risk of injury.

4.3. Introduction of day-old chicks

Chicks arrived in plastic containers about 15 cm high, the floor area and number of chicks in the containers may vary with hatching company, but there were at least 2000 chicks in each container. They were delivered by a truck and wheeled modules of about 12 containers were moved into the sections by hand. The introduction to the section was carried out at a temperature of 26 °C, the temperature was going to be raised to be 32 °C just after the introduction but was kept lower for the convenience of the workers, and in guiding light, as dark as possible with just enough light to see. The introduction began at the innermost end of the section, stacks were then moved further and further to the other end of the section as the chicks filled up the area, chicks had access to the whole section from the beginning. Chicks had plenty of space (Figure 7) and rows of paper cover with feed were placed in proximity to the drinkers to encourage feeding and drinking (Figure 8). Chicks were poured out of the container and to prevent them from squeezing the chicks in the bottom one quick shake of the container was combined with the pouring motion. During 50 minutes two persons inserted 29 500 chicks to a section of 1225 m^2, which would mean 1888 surplus animals if a mortality of 3 % is expected. The risk of injuries observed was primarily the risk of the chicks being stepped on or ran over by the container modules, which did happen. In one of the sections there was daylight entering the section and the chicks were much more active there than in the other section where it was dark. The risk of injury was higher when more light was present. Almost no chicks were injured during the darkest introduction. Chicks were observed to be much calmer in the dark environment, staying at the place where they had been poured out from the containers in contrast to the ones inserted in the lighter environment were the chicks ran around and did not stay in place and were attracted by daylight and actively sought out the lighter areas.

Figure 7. Space at the day of introduction.

Figure 8. Feed-covered paper near drinkers.

Chicks also reacted very strongly to any sounds aside from their own vocalizations, why the utmost silence possible was required to keep the chicks calm and minimize the risk of injury.

4.4. Loading

The loading was performed by the same company but there were a total of four teams whereof two performed the observed catching. The speed of the conveyer belt was 1.2-1.5 m/s when loading animals at full capacity. Fall height from the conveyer belt to the containers was 0.3-1.0 m and from the top container to the litter 1.7 m. The noise level near the catching machine was 90 dB. Results from the clinical examinations are shown in Table 2, no remarks were made on legs, wings, or breast at catching and no remarks were made on legs or wings at slaughter, these parameters are therefore excluded from the table. Bruises found on wings were small and superficial. Number of birds examined at the catching was 60, 40 control and 20 treated (that had fallen or jumped), and the number examined at the slaughter plant was 46, 28 control and 18 treated.

Table 2. Results from the clinical examinations.

Catching	**N examined at catching**	**N foot pad dermatitis**	**N examined at slaughter**	**N bruised wings**
1				
Control	10	9	6	0
Treatment	5	5	5	0
2				
Control	10	3	8	0
Treatment	5	3	4	0
3				
Control	10	7	9	0
Treatment	5	3	4	0
4				
Control	10	7	5	0
Treatment	5	2	5	2

4.5. Transport

During loading several critical control points were identified. We found that birds that were not fit for transport still were loaded into vehicles, see Figure 9 below. Birds loaded at the front of the motor vehicle and the trailer was cold and showed reduced overall condition at arrival at the slaughter plant. Wet and cold birds were found in the transport vehicles before departure, see Figure 10 below, and were cold and showed reduced overall condition at arrival at the slaughter plant. It was observed that the containers were wet before the loading of the birds started. During all transports observed the same stocking density was used, the temperature varied from approximately -3 °C to 10 °C. Some birds was also observed to have feathers, a wing or the head sticking out of the container handles, this can be seen at the bottom of Figure 6.

4.6. Stocking density

The stocking density is calculated from mean weights and number of animals from each section or each pair of sections, accounted for by the slaughter plant or the producer. Crowding occurred at 22 of 33 sections (67 %), 10 sections had a stocking density of 36-37 kg/m^2, 5 sections had a stocking density of 37-38 kg/m^2, 6 sections had a stocking density of 38-39 kg/m^2 and 2 sections had a stocking density of 39-40 kg/m^2. 45 sections had ventilation capacities exceeding

Figure 9. Lame bird not fit for transport loaded on the transported to slaughter

Figure 10. Wet birds loaded on the transport to slaughter.

36kg/m^2 ranging from 37-40 and 42 kg/m^2 and 25 sections had a ventilation capacity of 36kg/m^2. 8 sections out of in total 33 sections had stocking densities that exceeded the ventilation capacity.

4.7. Condemnations

Figures are based on total numbers from all flocks in one batch from all farms. Total number of animals slaughtered during the study was 1 915 816 and the total number of condemnations was 37 719 (2.0 %). Slaughter injuries (Group 8 in the condemnation form, see Appendix), which are injuries caused after arrival at the slaughter plant, accounted for 11 846 (31.5 %) condemnations, with 8 429 (22.4 %) condemnations due to mechanical injuries, mechanical injuries meaning injuries caused by mechanical failure in the slaughter line including post-mortem injuries not affecting bird welfare. Excluding slaughter injuries the total number of condemnations was 25 873 (1.35 %). The most common reasons for condemnation are shown in Figure 11.

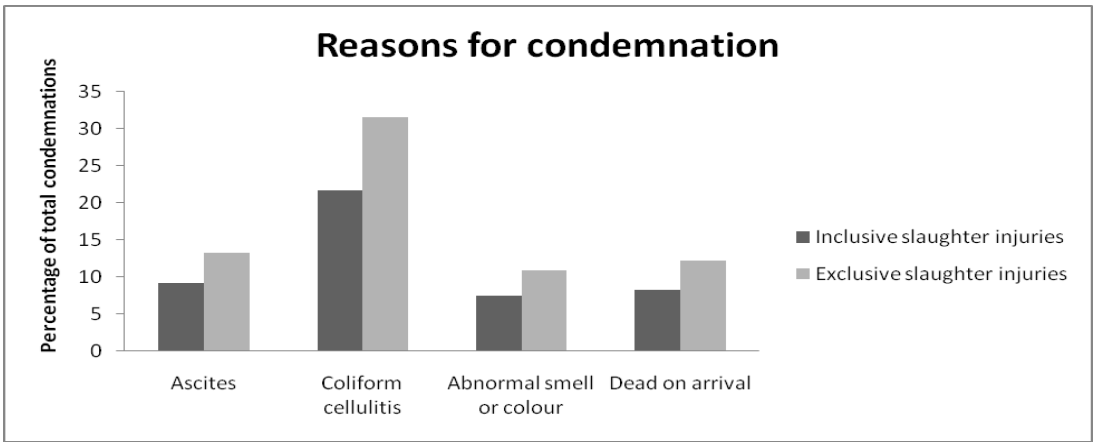

Figure 11. The most common reasons for condemnation of broilers slaughtered in the county of Södermanland

4.8. Foot score

A total of 46 foot score registrations were conducted on birds from 71 sections, 12 of these registrations (26 %) resulted in a remark on a high level and eight (17 %) resulted in a remark on a low level. 27.4 % of the feet examined had mild lesions (score 1) and 18.6 % had severe lesions (score 2). The lowest score obtained was 0 and the highest score obtained was 185. In total 4 600 feet corresponded to 1 915 816 birds and the number of broilers from which 100 feet were sampled from varied between 10 571-81 186. During 2011 four producers in Sweden had to decrease stocking densities as a consequence of high foot scores (The Swedish Poultry Meat Association, 2011 g).

4.9. Critical control points

Table 3 describes the critical control points identified for broiler welfare, giving an overview of the most important aspects of ensuring good welfare.

5. Discussion

The most severe animal welfare problem with Swedish broiler production is that the fast-growing hybrids used are prone to lameness, disease and unnatural behaviour. To switch to slow-growing hybrids would ease this welfare problem, but it has financial and practical concerns since slow-growing hybrids has a slower growth rate, they require more feed per kg live weight gain and require a longer period of time to achieve the same slaughter weight as fast-growing hybrids. This means that it will cost more for the producer to rear slow-growing hybrids, that it will be more complex to fit these birds into the slaughter system, and that the finished product is going to be more expensive for the consumers. Hopefully, if consumers are given the information about what the extra cost translates to in terms of broiler welfare they will be willing to pay for it. Supporting this view is that the sale of e.g. organic eggs, fresh chicken and meat cuttings has increased during the last years (KRAV, 2012 a) and that new Swedish books regarding animal welfare and environment are written and sold, e.g. Matens pris (~The price of food) written by Olofsson & Öhman in 2011 and Hur mår maten? (~How is the food feeling?) written by Per Jensen in 2012.

Another problem is that there is no room for mistakes without reduced welfare for the birds, the rearing is very sensitive to changes. The producers have the exact amount of feed required for the preset number of days it will take the broilers to achieve the determined weight, if something happens that would require the broilers to stay a day extra

on the farm there is no extra feed for that day. A problem with overcrowding and ventilation can also occur if slaughter is delayed or if broilers grow better than expected and exceeds the allowed stocking density and ventilation capacity. The section should also be cleaned between batches and one important part of the cleaning process is to let the section dry to kill disease agents. The next batch is already incubating when the previous one is sent to slaughter and will hatch and be delivered on the set date, meaning that the dry period will be shorter if the previous batch is delayed which may compromise the health of the next batch. This is a risk factor but it does not really occur in practice.

Another thing that is worth questioning is that an organization with extensive economic interest in broiler production is responsible for a broiler welfare programme that may have negative economic impact on the producers. The Swedish Board of Agriculture has approved that The Swedish Poultry Meat Association is running a broiler on-farm welfare programme, measured by e.g. high mortality or high foot scores at slaughter. To routinely report these figures to the County Administrative Boards could serve as a part of the quality control of the animal welfare programme, as the responsibility for the

Table 3. Critical control points summarized from literature, observations and interviews.

Element of rearing	**Critical control point**	**Comment**
Introduction	Light	Light attracts and activates chicks
	Sound	Sound attracts and activates chicks
	Temperature	
	Age of mothers	
	Chick activity level	Active birds may be stepped on or run over
Behavioural restriction	Genotype	Control lameness, growth rate and weight by switching to slow-growing strains
	Outdoor access	Promote activity
	Enrichment	Promote activity
	Period of dark	Slow growth rate and decrease body weight
	Feed restriction	Slow growth rate and decrease body weight Lead to hunger
Lameness	Genotype	Control lameness, growth rate and weight by switching to slow-growing strains. Select for improved immune responsiveness
	Culling	Remove lame individuals at least twice a day
	Outdoor access	Promote activity
	Enrichment	Promote activity
	Period of dark	Slow growth rate and decrease body weight
	Feed restriction	Slow growth rate and decrease body weight
Feet and hock burn	Wet/sticky litter	Nutrition, ventilation and stocking density affects litter quality
	Genotype	Selection for body weight and body weight combined with foot pad dermatitis
Disease	Genotype	Control growth rate and weight by switching to slow-growing strains, breed for increased immune capacity
	Culling	Remove sick individuals at least twice a day
	Biosecurity	

Feed	Nutrients	Minimize over and undersupply
	Water	Minimize wet litter caused by water spillage
Air	Ventilation	Remove excess heat, moisture, gases and dust
	Heating	Decreases humidity
Light	Period of darkness	
	Daylight	Provide a more natural environment Increase bird activity Improve working environment which may improve supervision of the birds
Stocking density	Number of inserted animals	
	Ventilation	Exceed allowed maximum stocking density
Supervision, inspections	At least twice a day	Cull sick or injured individuals

Table 3. Critical control points summarized from literature, observations and interviews.

Element of rearing	**Critical control point**	**Comment**
Catching	Speed of the conveyer belt	
	Conveyer belt walls	A must to prevent injury
	Container stocking density	
	Light curtains	A must if carried out during light hours
	Dry containers	
Transport	Temperature	Must be easily regulated and monitored
	Ventilation	Weather dependent, adjust ventilation if cold weather to prevent chilling wet birds
	Container stocking density	Weather dependent, must be lower when hot weather
	Container handles	Birds may be injured if body parts are sticking out of the handle openings
	Stocking density inside the transport	Weather dependent, some areas of the cargo area are not suitable during some weather conditions
Slaughter	Minimize period from catching to slaughter	Minimize time without feed and water, ensure mechanical function
	Gas stunning	Can be irreversible, no handling or shackling of conscious birds, improved welfare
	Electrical stunning	Reversible, handling and shackling of conscious birds, uncertain stunning of all individuals, resulting in poor welfare due to pain and risk of suffering if stunning does not work
	Container handles	Birds may be injured if body parts are sticking out of the handle openings
Personnel	Knowledge	Ensure proper training or experience
	Routines	
	Action plans	In case of accidents

official control of on-farm animal welfare lies with the County Administrative Board.

As management is the most important variable for welfare (Dawkins, 2004) the strength of the production is the producers, who possess a lot of knowledge about how to manage the broilers and their environment. A tool producers can use to tackle the problem with lameness is to cull affected individuals as culling is a way to minimize suffering. Producers cannot really influence which hybrids are offered and thus will have to keep on trying to prevent the symptoms of different issues rather than removing the underlying causes. They are also trying to improve the welfare, e.g. by constantly working with and adjusting the ventilation to try and get better litter, this might work better if producers were able to be more flexible regarding the stocking density and slaughter weight.

5.1. Rearing

One of the main reasons for rearing broiler indoors is to protect them from disease, however imported feed is the main source of *Salmonella* and *Campylobacter* is to some extent present in indoor-reared flocks (Wierup, 2006; The National Veterinary Institute, 2010), this information should be conveyed to consumers, and the producers, allowing them to make a choice regarding outdoor access. Fast-growing hybrids reared conventionally only live for five weeks which is too short for outdoor access to be feasible, KRAV-reared broilers who live for 10 weeks are allowed to be kept indoors until one month of age, if conventional producers switch to slow-growing strains outdoor access is possible for a larger part of the rearing period and therefore more feasible.

Only between a third and quarter of the broilers in this study had access to daylight, reasons stated by producers were that the broilers inflicted more injuries on each other in terms of skin scratches and that there was a risk for pile-ups. Some skin scratches were seen at all farms but no research was found regarding the effects of daylight on skin scratches. However, there are good ways to design, place and control daylight inlets (Secher, 2007; Hjalmarsson, 2008; Metlid, 2009; Metlid, 2009 a).

One reason for producers shortening the period of darkness may be that the broilers have not reached the desired body weight and the producers are trying to get them to eat more and grow more by increasing the amount of waken time, which is a misconception (Prescott et al. 2004).

At all farms, sick broilers that had been missed in the previous inspection round or become sick since then and in need of euthanasia were found. This indicates that the possibility to maintain a high welfare in the large groups that broilers are kept in is questionable, from an ethical point of view, meaning that the large groups makes it very difficult to spot all sick and injured birds at each inspection round. This also points to the fact that supervision and inspection rounds are very important to maintain a high welfare. Few broilers found dead indicates good welfare either in the sense of that the mortality is low and/or that few broilers die from injury, disease, starvation or dehydration but are instead culled. However there are lot of unsupervised hours for broilers to die on during a day and how many found dead could depend on a lot of things; skills of the personnel carrying out the inspections and the culling, barn temperature and humidity, age of the mothers and disease (Butterworth, 2004; Yassin et al. 2009; Widowski, 2010). There is an obvious need for an independent investigation of the health status of the Swedish commercial broilers.

To increase activity, spin feeders that disperse feed on the ground can be used (Jordan et al. 2011), ground feeding also promote a more natural foraging behavior with the different movements involved, i.e. ground scratching and pecking (Dawkins, 1989) Figures on the prevalence of ascites, sudden death syndrome, deep pectoral myopathy,

femoral head necrosis and coliform cellulitis during the rearing period in Swedish batches are collected, but not published, by the Swedish Food Agency. Future research on the mapping of these diseases is desirable to be able to assess the magnitude of suffering caused by these disorders.

5.2. Stocking density

As the stocking density in the section increases the broilers will have to utilize more and more of the total space, including patches or areas of wet litter, if such are present. Hence all animals will not have a dry and clean space to lie on at the end of the rearing period which leads to decreased welfare. From the interviews it was clear that producers had difficulties maintaining good litter quality during the rainy seasons of the year, why seasonal stocking density might be a good option. One idea proposed by a producer was to allow an increased stocking density with 1 kg in the summer, when it is easy to maintain a good litter, and decrease the stocking density with 1 kg during an equal period of time when it is hard to maintain good litter, e.g. the fall.

The data from this study showed that overstocking occurred at 67% of the sections which raise a concern that it may be common with decreased welfare associated with high stocking density (Saif, 2008; Buijs et al. 2009; Buijs et al. 2010; Berg et al. 2012). Sources of error in calculating the stocking densities may be that the scale at the slaughter plant did not work properly and that the heaviest broilers may not jump onto the elevated scales at the farms. Even so, this would mean that the weighted mean weight would be lower than the real mean weight making the overcrowding larger than calculated and thus underestimated. Even if the numbers are rough estimates they indicate that crowding is common and possibly higher than calculated. All slaughter plants connected to The Swedish Poultry Meat Association register the actual stocking density for every flock. These figures are not published for each farm but a compilation of Sweden can be found in the yearly report made by The Swedish Poultry Meat Association to the Swedish Board of Agriculture. However the latest available report on this showed the stocking densities in 2010, where very little overcrowding was reported. This is in contrast to the results obtained in the present study, possibly because the figures in the report cover a longer period than the period in the present study. Even if these figures are today not routinely reported to the County Administrative Boards, it is advisable for the County Administrative Boards in counties where broiler production exist to routinely request them from the slaughter plants. Or even better, if these figures were routinely reported to the County Administrative Boards by the slaughter plants as they already report this to the Swedish Poultry Meat Associaton.

5.3. Loading

The number of birds examined at the slaughter plant was less than the number examined at the farm site, a reason for this is that after exit from the gas tunnel many birds lay on their dorsal side thus hiding their marked back and making it difficult to spot the marked birds. Also, the containers holding the birds were too wide for a single person to be able to reach the entire container, a single person reached about half the container. Because of the high speed of the slaughter in combination with the width of the containers it was not possible to turn all the birds facing up and therefore some marked birds were missed. Should a similar study be performed it is recommendable to mark the birds on both the dorsal and the ventral side.

No injuries was found, suggesting that the catching method does not pose a risk for the birds, however the extent and sample size of the previous study was small why the results might have been different if these would have been bigger.

5.4. Transport

Stocking density of birds in the containers should be adjusted according to season and outside temperature (SJVFS 2008:69, L5), this was not found to be practiced, which is worrying. It is the driver of transport who has the responsibility for stocking density in the containers. Broiler dead on arrival is not necessarily due to factors on the production site, catching, loading and transport is likely the most stressful experience the broilers will encounter (Elrom, 2001).

Wet and cold birds were found in the transport vehicle, possible reasons are that the containers holding the birds were not dried properly at the slaughter plant and thus were wet when birds were loaded into the containers. It could also be due to the weather because the air inside the rearing section was warm and moist and the air flowing in from outside during the loading was cold which could cause condensation in the containers. After data collection for this study efforts have been made from the slaughter plant to improve drying of containers and to regulate the inflow of cold outside air into the transport (Tomasz Dzieciolowski, Lantmännen Kronfågel AB, personal contact, October 25th, 2012). The loading personnel aimed to raise the temperature at the loading site at future loadings (Martti Hämälä, PTTM Last AB, October 25th, personal contact, 2012). It is stated in the animal welfare programme that the containers must be clean and dry and that this should be done manually if the mechanical way fails to do so (The Swedish poultry association, 2011 e). Dryness of the containers may be easily checked before starting to load the birds and therefore this can be used as a critical control point if a HACCP approach would used on catching, loading and transporting broilers to slaughter.

It is stated in Swedish legislation (SJVFS 2008:69, L5) that animals getting sick or injured during transport must be prioritized as soon as possible be given veterinary care or if necessary be euthanized. However it is not possible to monitor the health status of every individual broiler because of how they are placed in the trailers. Even if the trailer is open only the lowest rows and the front-most birds in each container can be seen and there is no way of retrieving them during transport. One could therefore argue that there is a considerable risk for unnecessary suffering of broilers who get sick or injured during transport and are not euthanized until they are slaughtered. There is no good or feasible solution to this because of the way broilers are transported, but by making sure that no animals that are not fit for transport are transported the suffering can be minimized. By adding a control of the broilers directly after arrival at the slaughter plant with immediate euthanization of affected individuals the time of suffering can be reduced. Adding to the legislation that a thorough inspection round must be carried out 1-2 h before the start of loading in each section and that broilers shall be inspected at the slaughter plant directly after arrival to the lairage area might ease these problems.

5.5. Slaughter and condemnations

Some bruising of the wings were found, which may arise when birds vigorously flap their wings in the containers when coming into contact with the gas in the gas tunnel at the slaughter plant (PTTM Last AB, personal contact, September 25th, 2012). This seems reasonable since poultry shows respiratory distress and avoidance of high concentrations of CO_2 (Raj, 1996: Raj, 1998). Results from studies comparing mechanical and manual catching are diverging, on study shows a higher number of injuries with manual catching

compared to mechanical (Knierim & Gocke, 2003) and one study did not find any significant differences (Nijdam et al. 2005), however there was still injuries including bruising and fractures present on mechanically caught broilers. Regarding stress parameters Nijdam et al. (2005) did not find any differences between the two methods while Delezhie et al. (2006) found mechanically broilers less stresses than manually caught ones. One conclusion that was agreed on was that both mechanical and manual catching is stressful.

Basically this was a good method of investigating the catching, but it resulted in a not so thorough investigation as intended. The shortcomings of this method was the high speed at each moment making it hard to do things as carefully as wished and the fact that it was not possible to stop the process of loading or slaughter, or to investigate the birds directly after arrival at the transport. Sources of error in the clinical examinations may be that some of the visits were announced which may have influenced handling and culling, the light and time at the catching was very limited making it hard to do thorough examinations. Time constraints at the slaughter plant may have affected the quality of the clinical examinations.

5.6. Foot score

Results obtained at this study regarding severe and high degrees of lesions were higher than those obtained by Berg (1998). Reasons for this may simply be that the prevalence of lesion has increased, or that the scores was obtained just during one season of the year and that scores was obtained once from fewer flocks. In the study by Berg (1998) 50 feet were collected from the birds slaughtered first and 50 from the birds slaughtered last in the same flock, this was to avoid effects of feet collected from birds staying in a place of the section with a non representative litter quality and hence, foot score, and to avoid sampling only birds reared in the same part of the section.

The litter quality can be very different at different places in a section but no research investigating how the litter quality can vary in a section and what effect that variation might have on the birds. At the slaughter plant in Södermanland where the present study was conducted the 100 feet was divided into four groups with 25 feet each which was evenly distributed over the slaughter occasion, one group at the beginning, one at the end and the remaining two in between. This is very preferable since it even further avoid effects of non representative samples and clustered samples. During the study the 100 feet could represent up to three sections which made it impossible to know which feet came from which unit. This has now been changed so that the sections are held separate during catching and transport and every section gets a separate foot score evaluation (Madeleine Nederman, Lantmännen Kronfågel AB, personal contact, February 5th, 2012) which also is very preferable since it makes it possible to trace the problem back to a particular section. The Swedish poultry association states that at the first occasion that a remark on a high level is made, the stocking density of the second next batch should be lowered with 2 kg/m^2. Several foot scores that correspond to remarks on a high level was observed but some producers state that no actions were taken by The Swedish Poultry Meat Association which is disturbing since this may indicate insufficient routines in the animal welfare program.

Almost every farm had patches of wet/sticky litter but at about half of the farms the area of poor litter was big enough to result in a remark and a comment in the welfare inspection check list, showing that poor litter is a problem that most producers battle with but in different extents. Also, some producers experienced bigger difficulties with maintaining a good litter during the cold and wet seasons in contrast to a few that

experienced little or no variation between seasons. There are many factors contributing to poor litter quality (Dawkins et al. 2004; Bessei, 2006) and a finger tip feel by the producer is necessary to maintain a good litter throughout the rearing period. That the litter can vary between very similar buildings that are placed closely together even further illustrate the complexity. Producers also believe that there is a balance between dry litter and coliform cellulitis caused by dry air, however these possible correlations and cause and effects needs to be further investigated. Problems with foot pad dermatitis is much more severe in the rest of Europe compared to Sweden (The County Administration of Södermanland, personal contact, December 3rd), which might have to do with the fact that Swedish broilers are reared at a lower stocking density.

5.7. Mortality

About 3 % of the animals die during the rearing period (Waldenstedt, L., The Swedish Poultry Meat Association, personal contact, November 14th, 2012) and this equals 2.5 million broilers each year. A mortality of 3 % is not considered high per se but when it is put into relation to the number of individual animals dying it is still a large number of individuals. To put this figure into perspective a comparison with pigs and cattle slaughtered can be interesting. During 2011 approximately 500 000 cattle and 2.8 million pigs were slaughtered in Sweden (The Swedish Board of Agriculture, 2011). The number of individual broilers dying during rearing is five times higher than the total number of cattle slaughtered and about the same as the total number of pigs slaughtered. The Swedish animal welfare legislation applies to every individual animal, as it states that “Animals should be treated well and protected against unnecessary suffering and disease” (SFS 1988:534, 2 §). It is impossible to apply the legislation on every individual, especially regarding broiler production where the numbers of animals kept in one single section are so many that it is impossible for the producer to keep track of every single animal. The number of animals in a flock varies between 20 000 – 120 000 broilers for the main part of the animals (The Swedish Poultry Meat Association d, 2011) and even with the lowest number of 20 000 animals it is clear that individual welfare cannot be assessed, all individuals cannot be seen since they are lost in the crowd. However, in the 2011 proposition for a new Swedish Animal Welfare Act, it is suggested that “Animals shall not be kept in such groups that cause individuals unnecessary suffering”, but if or how this will apply to broilers is not clear (SOU 2011:75).

5.8. Broiler breeders

Features desirable for broiler breeders are less need for feed restriction and flock uniformity, that all birds perform as equal as possible. Less requirement for feed restriction may mean that the focus on high growth rate needs to be alleviated and flock uniformity reduces competition which in turn prevents birds from getting more hungry, not getting their ration and getting injured (EFSA, 2010). At slaughter, the shackling may injure the birds when done prior to stunning and voltage and/or current may be to low when using electrical stunning, overall the slaughter practices must be adjusted to the higher weight of the breeders (EFSA, 2010) and it would be very preferable to switch to gas stunning to improve the welfare at slaughter on these heavy birds. The main hazards for decreased welfare for broiler breeders are the use of fast growing hybrids, high levels of ammonia and exposure to feather pecking (The County Administration of Östergötland, 2012).

5.9. Consumers

For consumers to be able to make well-informed choices it is necessary to provide alternatives and information about the alternatives' differences. As of now there are only products available from fast-growing broiler hybrids, and organic products have very low availability as production is so small. Therefore the conclusion that consumers only want cheap products cannot be drawn. The consumers do not have anything else to base their purchases on than the price, since no other information on what separates imported products from Swedish products is available in the stores. A labeling system ranking the welfare of different products and is a good idea to make it easy for consumers to understand the information. A good example of a supermarket chain that is trying to invest in higher welfare is Coop in Italy that within the next five years aims to only sell broilers reared with stocking densities of 30kg/m^2, daylight inlets, perches, environmental enrichment such as pecking objects and straw bales and a leg health programme (The County Administration of Södermanland, personal contact, December 13th, 2012).

6. Recommendations for increased broiler welfare and reduced risks of welfare problems

- Genotype:
  - Switch to slow-growing hybrids to promote health and natural behaviour
  - Breed for sustainability, health and natural behaviour. Breed strains adapted to the Swedish climate if outdoor access is granted
- Business
  - Add resources to find solutions on how to design daylight inlets and to implement these on farms
  - Add resources to find solutions on how to prevent wet litter and how to improve the litter when it is wet
  - Grant consumers a higher transparency into the production to establish a more trustful relationship
  - Grant consumers choice and information about what the different choices mean and why the price may differ. E.g. as of today only fast-growing broiler meat is available in the commercial stores
  - Be consistent in actions taken in case of high foot scores and do not change the action plan to milder actions, it is not about making it more difficult for the producers but to provide a better environment and welfare for the broilers
  - Report the true stocking densities and the foot scores routinely from every slaughter to the County Administrative Boards.

- Management:
  - Meticulous and uncompromised culling of sick or injured birds at least twice a day. Smaller groups of animals helps identifying affected individuals
  - Invest in good designs of daylight inlets, do not view daylight as something negative but instead as a possibility to provide a better environment for your animals and personnel
  - Improve the litter quality during humid outdoor seasons, top-dress the litter, lower the stocking density during the rainy season and compensate producers by allowing a higher stocking density during the dryer season.

- Use outdoor access to promote natural behavior and health
- Use spin feeders indoors to promote activity and prevent lameness
- Switch to controlled atmosphere stunning where the birds remain in the containers until after stunning to improve welfare at slaughter by avoiding tipping of the containers, conscious shackling and water-bath stunning

7. Conclusions

The strengths of the production are the producers who are constantly working with improving the environment and have a lot of knowledge and the high biosecurity throughout the production chain. The main weaknesses is the overall vulnerability of the production in terms of the problems that arise if broilers cannot be sent to slaughter at the pre-set date and the use of fast growing hybrids which has implications for welfare. The possible solutions to these issues today are to give the producer more influence over the production and to switch to slow-growing hybrids. A number of risk factors covering the period from introduction to slaughter were identified, with the use of fast-growing hybrids being one of the most common ones. Introduction of day old chicks is carried out in as dark an environment as possible. Lameness is a significant welfare problem in broilers. Mechanical catching before transport to slaughter pose a risk of injury, though less of such than manual catching, however it was not shown to cause any significant injuries to broilers in this study.

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9.1. Personal contacts

September. (2012) Bjärefågel i Torekow AB, Ingemarsson, M., September 26th, 2012; Guldfågeln AB, Nilsson, M., September 17th & 26th, 2012; Knäreds Kyckling AB, Karlsson, J., September 7th & 26th, 2012; Lantmännen Kronfågel AB, Nederman, M., September 7th & 25th, 2012

10. Appendix

JOURNAL OF REGISTRATION OF PATHOLOGICAL CHANGES; POULTRY

Type of animal Broiler

		Number	Comment
1.	**CHANGES IN ABDOMINAL- AND CHEST CAVITY**		
11	Liver damage		
12	Intestinal inflammation		
13	Oviduct- or peritoneum inflammation		
14	Lung-, pericardium- or air sac infl.		
15	Kidney inflammation, gout		
16	Ascites		
17	Gizzard – stomach dilation		
18	Yolk sac inflammation		
	Sum		
2.	**TUMORS**		
21	Leukosis or Marek's disease		
22	Other tumors		
	Sum		
3.	**LAMENESS**		
31	Joint-tendon sheat inflammation		
32	Older injuries or fractures		
33	Other leg disorders		
	Sum		
4.	**POOR CONDITION**		
41	Emaciation		
42	Muscle atrophy		
43	Small underwieght		
	Sum		
5.	**SKIN DISORDERS**		
51	Coliform cellulitis		
52	Sternum bursitis		
53			
	Sum		
6.	**OTHER**		
61	Abnormal smell or colour		
62	Euthanized, not slaughtered		
63	Other causes		
64	Hard fillets		
	Sum		
7.	**FOUND DEAD**		
71	Dead on arrival		
72			
	Sum		
8.	**SLAUGHTER INJURIES**		
81	General redness of the skin		
82	Haemorrage, fresh fracures		
83	Abscence of internal organs		
84	Mechanical injuries		
85	Poorly bled		
86	Uncut		
	Sum		

	Number	
Total number added		Percent
Total number condemned (1-8)		
Total number approved		
Total condemn. deduction on payoff		

Week

Date

Supplier

Unit

Official veterinarian signature

Foot health:

0:

1:

2:

Score:

Appendix. Form used at a Swedish slaughter plant for registration of condemnations.

Vid **Institutionen för husdjurens miljö och hälsa** finns tre publikationsserier:

*** Avhandlingar:** Här publiceras masters- och licentiatavhandlingar

*** Rapporter:** Här publiceras olika typer av vetenskapliga rapporter från institutionen.

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