Comparison of behaviour and health of two broiler hybrids with different growth rates

Jämförelse av beteende och hälsa hos två kycklinghybrider med olika tillväxttakt

Sofia Wilhelmsson

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Agronomprogrammet – Husdjur

Studentarbete **Nr. 637**
Sveriges lantbruksuniversitet
Institutionen för husdjurens miljö och hälsa

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Nivå Avancerad E, 30 hp, Agronomprogrammet – Husdjur, Examensarbete i Husdjursvetenskap/Master in Animal Science - E30, EX0567

Handledare: Jenny Yngvesson, Institutionen för husdjurens miljö och hälsa, Box 234
532 23 SKARA
Examinator: Lotta Berg, Institutionen för husdjurens miljö och hälsa, Box 234
532 23 SKARA

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Sveriges lantbruksuniversitet
Fakulteten för veterinärmedicin och husdjursvetenskap
Institutionen för husdjurens miljö och hälsa
Box 234, 532 23 SKARA
E-post: hmh@slu.se, **Hemsida:** www.slu.se/husdjurmiljohalsa

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SUMMARY

Until recently fast growing broiler hybrids have been used exclusively in both conventional and organic broiler production in Sweden. This study aimed to quantify differences in behaviour and health between a fast growing hybrid (Ross 308) and a slower growing hybrid (Rowan Ranger). The chickens were reared for 10 weeks in a semi-organic production environment with organic feed and space allowances, but without outdoor access. In the study, 218 Ross 308 and 211 Rowan Ranger day old chicks were split into 20 groups with 10 replicates of each hybrid. Registrations of behaviour and health were done at 2, 6 and 9 weeks of age and mortality was recorded continuously from start to slaughter. Behaviours were recorded through scan sampling and continuous observations. The day after the behavioural observations, a welfare assessment was performed according to the Welfare Quality® Assessment Protocol for Poultry. The results showed that Rowan Ranger chickens were more active than Ross as they were standing more, furthermore, Rowan Ranger were perching more than Ross. Ross chickens had more leg and feet problems than Rowan Ranger chickens, i.e. worse gait score (decreased moving ability), foot pad dermatitis score and hook burn score (inflammation and lesions on the skin). As a result of more severe leg problems, a higher proportion of the Ross compared to the Rowan Ranger birds were culled. Both Ross and Rowan Ranger showed health problems at older ages, likely due to increased body weight in both hybrids. However, results imply that fast growing Ross 308 chickens are poorly suited for a long rearing period (>10 weeks), whereas the slower growing Rowan Ranger chickens seem better suited for the rearing period of 81 days stated by the organic regulations.

SAMMANFATTNING

Fram tills nyligen har enbart snabbväxande slaktkycklingar använts i såväl konventionell som ekologisk kycklingproduktion i Sverige. Syftet med det här examensarbetet var att kvantifiera skillnader i beteende och hälsa mellan en snabbväxande hybrid (Ross 308) och en mer långsamväxande hybrid (Rowan Ranger). Kycklingarna föddes upp under 10 veckor i semi-ekologiska förhållanden, med foder och utrymme enligt ekologiska regler men utan tillgång till utevistelse. I studien ingick 218 stycken Ross 308 och 211 stycken Rowan Ranger-kycklingar, som delades upp i 20 grupper med 10 upprepningar av varje hybrid. Registreringar av beteende och hälsa gjordes när kycklingarna var 2, 6 och 9 veckor gamla och dödlighet registrerades kontinuerligt från insättning till slakt. Beteenden registrerades med Scan sampling samt kontinuerliga observationer. Dagen efter beteendeobservationerna gjordes en välfärdsbedömning i enlighet med Welfare Quality® Assessment Protocol for Poultry. Resultaten visade att Rowan Ranger-kycklingarna var aktivare än Ross då de stod upp mer och de använde också sittpinnarna mer frekvent. Ross hade mer ben- och fot problem än Rowan Ranger, det vill säga högre värden för gait score (sämre rörelseförmåga) samt foot pad dermatitis- och hook burn score (hudinflammationer på fotsula och has). En högre andel Ross kycklingar avlivades på grund av svåra benproblem jämfört med Rowan Ranger-kycklingarna. Trots att både Ross- och Rowan Ranger-kycklingarna uppvisade ökade hälsoproblem med ökad ålder och vikt så visar resultaten att Ross-kycklingar är sämre lämpade för en lång uppfödningsperiod (>10 veckor) än Rowan Ranger.

CONTENT

Abbreviation List

cm= Centimetre
e.g.= for example (*exempli gratia*)
FCR = feed conversion ratio
FG= Fast growing
FPD= Foot pad dermatitis
G= Gram(s)
HB= Hock burn
i.e.= that is (*id est.*)
Kg= Kilogram(s)
m^2= Square meter
Min= Minute(s)
OB= Organic broiler
R= Ross 308
RR= Rowan Ranger
SG= Slower growing
TT= Touch test

INTRODUCTION

Several factors have likely influenced the choice of which species humans have domesticated and now use in food production. Amongst other qualities, it is crucial that the animals can survive and reproduce in enclosures alongside humans (Mignon-Grasteau et al., 2005). It is known that chickens (*Gallus gallus domesticus*) are the most common food producing species worldwide, partly because they meet the criteria above, and their numbers are still increasing. The quantity of broilers produced for meat each year is vast. In 2013, there were more than 60 billion meat type chickens slaughtered in the world (61,171,974,000). Over 6 billion (6,654,786,000), or 11 % of that total production was in Europe. Of the chickens produced in Europe, about 82 million (81,826,000) i.e. 1%, was produced in Sweden (FAOSTAT, 2015). Over the last 50 years, the Swedish broiler production has made a fivefold increase in the number of chickens slaughtered, and a sixfold increase in tonnes meat produced per year (FAOSTAT, 2015) (fig. 1). These numbers indicate a development of the efficiency of the production in general and the broilers specifically.

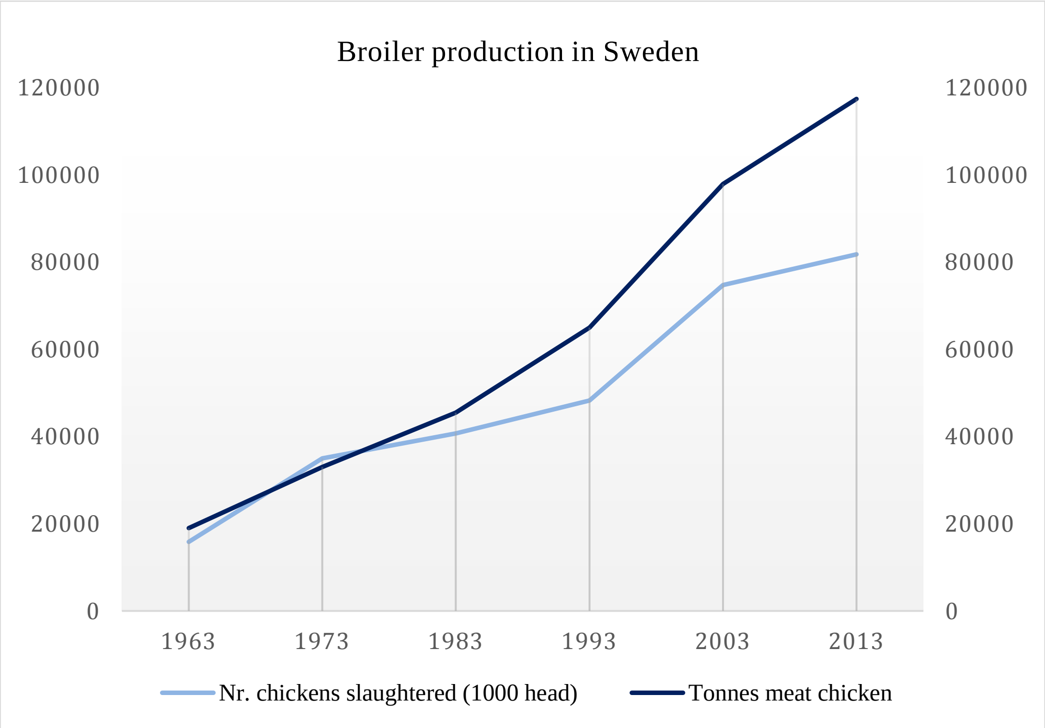

Figure 1. *Tonnes broiler meat produced and number of slaughtered broilers in thousands in Sweden over 50 years, from 1963 to 2013 (FAOSTAT, 2015).*

Breeding has drastically improved the efficiency of production traits in broilers, such as FCR and weight gain. It is the high heritability of these production traits that has enabled the development of the production (Nicol, 2015). Commercial breeding of broilers started in the 20th century resulting in a quadrupled growth rate. The increase in growth rate can be linked to high mortality rates and diseases along with inactivity, due to imbalanced bodies with large breast muscles (Muir and Aggrey, 2003, Weeks et al., 2000, Shim et al., 2012, Bessei, 2006). Beside breeding and genetics, nutritional and management improvements also have enabled the increased growth rate (Cooper and Wrathall, 2010).

In 51 years, between 1956 and 2007, the average weight gain increased from 21 to 63 g/ day, enabling a live weight of about 2.2 kg in 35 days (at slaughter) (Aviagen, 2014b, Aviagen, 2014a).

Increased consumption of chicken meat have lead to a 25 % increase in the poultry meat production in Sweden over the last 10 years, even so, the self-sufficiency rate has decreased with about 10 % in the same period (Jordbruksverket, 2015). One contributing factor is the organic broiler (OB) production that doesn't seem to correspond with the increased demand for organic products and constitute only a fraction, about 0.1 %, of the total broiler production in Sweden (Jordbruksverket, 2013). The broiler production in Sweden is currently too small to finance a national breeding program. Instead, breeding stock consisting of broiler grandparents are bought from breeding companies in USA and UK as day old chickens (Thiruvenkadan et al., 2011). The grandparents then produce broiler parents that are distributed to about thirty Swedish hatcheries that hatch the broilers and sell day old chicks to about 120 broiler producers (SvenskFågel, 2015).

The reason for the slow development of OB production in Sweden is multifactorial, Swedish OB producers need to consider EU legislation, the International Federation of Organic Agriculture Movements (IFOAM) regulations and additionally, by choice, KRAV's regulations. EU legislation and KRAV's rules state that fast growing (FG) hybrids need to reach 81 days before slaughter and grow a maximum of 50 g/day (KRAV, 2015a) something that is in conflict with what they have been bred for and leads to negative welfare implications (Castellini et al., 2002). Lack of slower growing hybrids that are adaptable to the organic forms of production (Nielsen et al., 2003) is another contributing factor and even though these chickens are recommended (Grashorn, 2006) by the regulations mentioned, FG broilers have been commonly used in Sweden for reasons such as availability and effectiveness (Sirri et al., 2011). The disallowance of pure amino acids in the feed and preventive medication for coccidiosis may reduce growth and the access to outdoor increases the risk of parasitic diseases (Blair, 2008) such as campylobacter (*C. jejuni*) and salmonella (*Salmonella*) spreading from wild birds (Bassler, 2008). Some factors are directly connected with the organic forms of production that distinguish from conventional production, primarily due to the prolonged rearing period and outdoor access (KRAV, 2015b).

The relatively long rearing period in OB production complicates the use of FG broilers, due to increased risk of diseases such as leg disorders and ascites connected to the rapid growth rate (Knowles et al., 2008). FG broilers suitability in these production environments, where low protein feed is needed to prevent them from getting too heavy, can therefore be questioned (Eriksson et al., 2009, Muir and Aggrey, 2003). Some European countries use slow growing (SG) broilers in OB production, and besides improved bird welfare, the nutritional content of the meat also differs from FG broilers (Waldenstedt, 2005), e.g. higher protein content in the breast-meat (Mikulski et al., 2011). Intriguingly Rowan Ranger, classified as a slower growing bird (Aviagen, 2015), recently entered the Swedish market.

Knowledge about chicken behaviour and health and how they respond in different environments is necessary to obtain a good animal welfare, but defining welfare is complex and includes many aspects such as animal health, physiology and behaviour as well as subjective experiences (Jensen, 2002). Therefor, it is preferable to use several parameters and different viewpoints when assessing welfare, to get as reliable results as possible (Waiblinger et al., 2006). It might be easy to see that an individual suffering from injury or disease has poor welfare, but a seemingly healthy animal that produces well does not necessarily have good welfare. Animals bred for high production can suffer from so called production diseases, e.g. mastitis in diary cows or leg problems in FG broilers. Selection for production traits also seem to lead to reallocation of energy from behaviours that cost much energy, such as social interactions, to be used for e.g. growth (Schutz and Jensen, 2001).

When assessing animal welfare, knowledge of their natural behaviours is necessary and depending on the viewpoint, a range of different results is possible (Jensen, 2002). Regarding broilers, measurements of mortality, behaviour and physiology can be used to estimate welfare (Dawkins et al., 2004). According to an EU-funded project, The Welfare Quality® project (FOOD-CT-2004-506508), four principles are used to assess farm animal welfare; “Good feeding”, “Good housing”, “Good health” and “Appropriate behaviour” (WelfareQuality®, 2009). Some of the most important welfare issues in broilers are poor leg health along with low prevalence of natural behaviour such as ground pecking (Weeks et al., 2000).

This thesis was included in the first part of a research project at the Swedish University of Agricultural Sciences in Uppsala, with the overall goal to contribute to a long-term sustainable development of organic broiler production in Sweden. The project was partly financed by The Swedish Farmers' Foundation for Agricultural Research. This thesis focuses on behaviour and health in two broiler hybrids with different growth rate, fast growing Ross 308 (R) and the slower growing Rowan Ranger (RR). The information collected in this study will hopefully contribute with significant knowledge about possible differences in behaviour and health between the two hybrids and ultimately show how well adapted the strains are for the developing OB production in Sweden.

Initially, a literature review was carried out in order to summarize some previous research of the behaviour and health of chickens reared for meat production and the impact different production systems have on broiler welfare.

Aim and hypothesis

The aim of this study was to quantify differences in behaviour and health between two broiler hybrids with different growth rate. The hypothesis was that there would be differences in behaviour and health between the hybrids.

The aim will be met by answering the following questions:

- How much time do each hybrid spend sitting, standing, eating, foraging, sleeping and perching and does it differentiate between the hybrids? Prediction: FG chickens will spend more time sitting, sleeping and eating and SG chickens will stand and perch more.
- How often do the different hybrids perform social interactions and behaviours such as; foraging, dustbathing, grooming, perching, playing, feather pecking (FP) and comfort behaviours and does it differentiate between the hybrids? Prediction: FG chickens will be inactive with very little social interactions while SG chickens will show more of these behaviours.
- Does the prevalence of impaired gait, Foot pad dermatitis (FPD), hock burn (HB) and mortality differ between the hybrids? Does the health status of the hybrids differ? Prediction: FG chickens will have a more impaired gait, higher mortality and more severe FPD & HB than the SG chickens.
- How do the hybrids relate to the production system (housing conditions) regarding litter quality, cleanliness and temperature (i.e. do they show panting and huddling behaviours?). Does the hybrids correspond differently to the housing conditions? Prediction: FG chickens will generate a more humid litter and perform panting to a higher extent while SG chickens will show huddling more and have a cleaner plumage.
- Do the birds show fear of humans and is there a difference in how much fear they show? Do the birds show positive or negative emotional states and does it differ between them? Prediction: SG chickens will show higher level of fear than FG chickens as well as more positive emotional states.

Target group

This study primarily addresses to actors within the Swedish broiler production as well as animal science students and scientists in general. It may also be of interest for countries with similar production conditions as Sweden.

LITERATURE REVIEW

Production systems

Understanding the consumer perspective on broiler welfare is necessary when reviewing standards and further developing production systems with increased welfare, since it enhances marketability and willingness to pay. Outdoor access and stocking density are examples of practices that matter to consumers (de Jonge and van Trijp, 2013). Different challenges come with different production forms. In a comparison of OB production with SG hybrids and a conventional production with FG hybrids carried out in the Netherlands, results indicated e.g. better bird welfare and net income in the OB production but also higher green gas emissions and more land use (Bokkers and de Boer, 2009). In contrast to previous research where FG and SG broilers were compared under organic forms of production (Bokkers and Koene, 2003, Nielsen, 2012), the present study was implemented on Swedish OB production forms (with the exception of access to outside space) and includes aspects of the Swedish national law and KRAV's regulations which distinguish from EU-standards regarding space allowance, dustbathing, growth rate and feed content (KRAV, 2015a).

Closed-housed systems are known to provide good biosecurity, however open-housed systems with varying temperatures has shown to lower fear-related behaviours in broilers and improves their coping ability at high-temperature transports (Al-Aqil and Zulkifli, 2009, Zulkifli et al., 2012). Temperature, humidity and litter quality, i.e. litter moisture and air ammonia, influence broiler health and distribution in the house more than stocking density (Dawkins et al., 2004, Febrer et al., 2006). However, management, i.e. the human error, seems to be the most critical factor for broiler welfare (Dawkins et al., 2004).

Different chicken genotypes fit certain environments, and the capability of chickens in different environments is influenced by their fundamental condition. Internal and external factors such as genetics, physiology, feed and environment have a direct impact on the chicken immune system (Qureshi et al., 1998). Breeding for higher productivity in FG broilers has lowered their immune function and caused an increase in susceptibility to stresses from the environment (Thiele, 2001). Even so, FG hybrids have a better growth capacity than SG in OB production, however they show higher mortality and culling rate and do not seem to adapt well to the that system (Castellini et al., 2002). Both growth performance and weight gain is impaired in SG broilers in free-range systems (Dou et al., 2009), however, SG hybrids are more adaptable to changes in the ambient temperatures using metabolic changes, appearing relatively unaffected. FG broilers on the other hand use behavioural changes such as inactivity to cope with increased temperatures (Nielsen, 2012).

Usage of resources is generally seen as the intention with outdoor access (Fanatico et al., 2005) and require animals to be active. For slow growing hybrids, with an average weight gain of 22 g/day, activity increase with age possibly depending on the increase in feed consumption together with higher confidence in exploring surroundings (de Almeida et al., 2012). Hybrids that have not been intensively selected for fast growth rate are more adaptive, have higher locomotor activity and therefor cope better with challenging conditions than FG birds (Castellini et al., 2002). Furthermore, SG broilers tend to have a higher outdoor activity than FG and forage more which can significantly compliment their nutritional needs (de Almeida et al., 2012). In order for pasture to increase the animal welfare, an adapted hybrid with well functioning immune system and suitable growth rate, i.e. good ability to cope with extensive production, is needed. About 10-20 % of chickens' dietary requirements can consist of grass (fresh, dried or ensiled) and the intake depends both on grass qualities as well as hybrid, rearing age and age of introduction to the pasture (Sossidou et al., 2015).

Time budget and genetics

Genes influence behaviour through heritage of metabolism and hormone levels and have a big part in the control of the behaviour, and in turn the interaction with the environment (Jensen, 2002). A combination of external (e.g. feed in sight) and internal (e.g. hormone levels) causal factors motivates chickens to perform certain behaviours (Nicol, 2015). One study made on laying hens (the same species, *Gallus gallus domesticus*, as broilers but primarily selected to produce eggs) showed that they are highly active and changes 70 % of their behaviours every 2 minute (Mishra et al., 2005). Changes in broilers behavioural patterns can be used to assess their well being, for example; leg problems will appear as a reduced motivation to walk (Nicol, 2015). Time budgets of domesticated chickens distinguish from their ancestors. The domesticated laying hen show less social interactions and foraging behaviour compared to the red junglefowl (*Gallus gallus*, ancestor of domesticated chickens), seemingly because of reallocation of the energy to production traits during domestication (Schutz and Jensen, 2001). Dawkins (1989) studied Red Junglefowl behaviour and found that they spent most of the active time of the day foraging (walking and pecking) and the rest of the time ground scratching, grooming, sitting and standing (amongst other) in that order of magnitude. The timebudget of laying hens seems to depend mostly on the environment provided, and less on genetics (Klein et al., 2000). The natural behaviour in FG broilers is greatly influenced by the fast growth, at eight weeks of age they spend as little as 1% of the time walking. The decreased mobility results in possible behaviour disorders such as increased grooming (Bokkers and Koene, 2003). Further, Weeks et al. (2000) found that lame broilers change their feeding strategy to eating whilst laying down half of the time.

Enrichment

Possibility to perform natural behaviours, such as perching, is essential for chicken welfare and providing adequate environmental enrichment is necessary to enable natural behaviour and to improve and assess welfare. The investigation of behaviours and emotions in broilers is complex, however, recent findings indicate the importance of some of the behaviours (Bokkers and Koene, 2004). Dustbathing is shown to reduce lameness in broilers (Stub and Vestergaard, 2001), also, signs of reduced dustbathing can be used as an indicator of decreased welfare since lameness reduce occurrence of dustbathing (Vestergaard and Sanotra, 1999). An enriched environment does not seem to effect the growth performance in broilers, on the contrary, it seem to decrease fearfulness and improve ability to cope with fear at older ages (Altan et al., 2013). However, there seems to be no clear improvement of motor activity, leg diseases or fearfulness in FG broilers with access to perches (Bailie and O'Connell, 2015). Due to Bizeray et al. (2002), the time budget of FG broilers changes when their environment gets more complex than in the commercial production. For example, perching behaviour is performed when possible, indicating welfare benefits.

The effect enrichment has on broilers seems to depend on both genetic and environmental conditions. Strain and sex of SG broilers in organic production seems to be more influential of the occurrence of breast blisters (caused by contact with wet litter) than usage of perches (Nielsen, 2004). In FG hybrid flocks usage and effect of perches seem to depend on age and stocking density, with a peak at about 5 weeks of age (Jiao et al., 2014). Further, activity levels of FG broilers reared outside is initially greater than if reared inside, but at six weeks of age the time spent lying is equal. Even though motivation for behaviours such as ground pecking remains at older ages, FG broilers make little use of enrichment such as perches and additional space, presumably due to leg problems (Weeks et al., 1994, Reiter, 2006).

Enclosure size is a crucial factor when it comes to use of space and movement patterns in broilers, density and group size affects as well but not to the same extent. Chickens seem to utilize and spread out in accessible space (Leone et al., 2010) and also seem willing to work for additional floor space when necessary (Buijs et al., 2011).

Emotions

Emotional states in chickens is a new area in animal science and needs further research. Fear is the most thoroughly investigated emotion in chickens, and they have a well-developed system for responses to threats. Stress can be connected to fear but can also be triggered for other reasons and is not necessarily bad for the chicken (Nicol, 2015). There are several measurements to use when looking at fear and stress in broilers, for example tonic immobility response, heterophil lymphocyte ratio in the blood, body weight, feed conversion ratios and mortality (Zulkifli and Azah, 2004). Recent research show that adaptability to stress is associated with the hypothalamic expression of genes regulating fear- and stress, and broilers with short tonic immobility (TI) have better serotonergic neurotransmission than those with long TI (Wang et al., 2014).

Bird-human interaction

Measuring behaviours such as avoidance of or approach to humans needs considering both if there is any discomfort regarding locomotor activity and also if size of the pen is large enough to enable measurable reactions. Further, it is important to consider the behaviour of the human observer (Waiblinger et al., 2006).

Fear of humans cause stress and contributes to the variation in FCR in commercial broiler production (Jones, 1993), however, this fear can be reduced by regular handling (Waiblinger et al., 2006). Stress and fear-reactions can be reduced by pleasant human contact while unpleasant contact instead increases negative response to transportation (Al-Aqil et al., 2013). Pleasant bird-human interaction might therefore increase production traits such as body weight and FCR (Zulkifli and Azah, 2004). Physical contact seem to reduce fear more effectively than visual and regular human contact can decrease bird-to-bird pecking (Zulkifli, 2008). An experiment made on laying hens where stationary person test, avoidance distance test and touch test were used to assess the hen-human relationship, showed that additional contact with the birds positively affected the relationship after a 2-week period. The distance between human and hens decreased and number of hens touched increased (Graml et al., 2008). Young chickens seem more susceptible to human behaviour than older ones, walking slow amongst very young chickens keep fear levels and in turn mortality down (Cransberg et al., 2000). Furthermore, Zulkifli et al. (2002) reported that a regular visual contact of humans in the 1-21 days can reduce fear reactions to handling, and that fear, stress and immune responses are interconnected.

Health

Disease and mortality in broiler production decrease chicken welfare and cause financial losses. The main health and welfare issues in broiler production are leg problems including lameness, contact dermatitis, ascites, sudden death syndrome, reduced mobility and thermal discomfort (Arnould et al., 2011). Decreased locomotor activity and leg health is associated with fast growth rate and most management factors that could increase broiler welfare also cause decreased growth rate and ultimately lower profitability (Knowles et al., 2008). Additional to fast growth; management and nutritional factors also influence leg health (Waldenstedt, 2006, Bessei, 2006). FG Broilers have higher mortality than SG broilers reared in organic conditions (Castellini et al., 2002) and Dal Bosco et al. (2014) claim that the welfare of FG broilers is bad at the later stages of the rearing period in organic production, and should therefor not be allowed as an alternative to better adapted SG hybrids.

Rapid growth rate together with relatively short legs and large breast-muscles seem to change FG broilers (Ross 308) centre of gravity, leading to decreased stability. Reduced mobility and inactivity might be a result of tiredness from trying to stabilize gait patterns through shorter, wider and slower (motion) steps (Corr et al., 2003). The locomotor activity in very young FG broilers seem to be correlated to older ages, thus selection of good mobility at an very early stage therefore might increase chicken activity later on (Bizeray et al., 2000). Leg weakness and pain influence gait as well; Shim et al. (2012) found that bone health defined as tibia breaking strength decreased with increased growth rate. Furthermore Naas et al. (2009) concluded that FG broilers feel pain and discomfort from 35 days of age, since chickens with impaired gait that received painkillers increased their walking ability significantly. Fifteen years ago Weeks et al. (2000) found that sound FG broilers (that were not found to be lame) spend an average of 76 % of their time lying down, whereas lame birds with gait score three spent 86 % lying down. Fast growth rate seem to be the main factor also for metabolic disorders, such as Sudden Death Syndrome and ascites, causing mortality (Bessei, 2006).

Except locomotor activity, management factors such as lighting-programs and feeding may cause chicken welfare issues (Reiter, 2006). Litter quality deteriorates with increased stocking density, stocking density can also elevate ambient temperature, leading to heat stress and panting (Bessei, 2006). Long term contact to litter with poor quality may cause contact dermatitis in chickens (HB, breast blisters and FPD), explained as lesions due to inflammation of the skin leading to tissue damage and possible secondary infection, this is a painful condition and considered a welfare matter (Bessei, 2006). Infectious diseases such as campylobacter might increase problems with HB and FPD due to increased moisture content in the droppings, possibly due to increased excretion of intestinal fluid (Williams et al., 2013). Contact dermatitis is not only an animal welfare issue; nowadays, intact paws are a valuable export to Asia (Shepherd and Fairchild, 2010), lesions might also lower carcass quality and thus cause economic losses (Broom and Reefmann, 2005).

MATERIALS AND METHODS

The experiment took place outside of Uppsala at Funbo Lövsta (latitude 60° north), at a Research Station of the Swedish University of Agricultural Sciences, in between 150521 and 150709.

Animals and housing

In total 429 day-old chickens of two broiler hybrids, Ross 308 (R) and Rowan Ranger (RR), entered the experiment. The chickens were given two different feed treatments and divided into groups with 19-22 chickens in each, without mixing of the hybrids (table 1). A mussel meal feed treatment was done simultaneously on other groups and is presented elsewhere. At 2 days of age, chickens were weighed and wing tagged and one day before each behavioural observation three focal animals in each group were colour marked (the same individuals throughout he study). The project's researchers carried out all treatments and observations. Weighing was performed continuously once a week with one registered weight per group. At the final recordings before slaughter, at 70 days of age, 391 chickens remained. Of the entering 429 chickens, 26 had been culled due to leg disease and 12 were found dead. Individual weighing took place on the day before slaughter.

Table 1. *Number of groups and number of chickens per treatment*

Treatment	Nr. of chickens at start		Nr. of chickens at end		Nr. of groups
	Ross	Rowan	Ross	Rowan	
High protein feed	110	106	100	102	10
Low protein feed	108	105	91	98	10
Total [1)]	218	211	191	200	20

[1)] Total numbers of chickens of each hybrid at the start and end of the experiment and total number of groups throughout the experiment

The chickens were kept indoors in a climate controlled stable, in pens measuring 1.85*1.85 m. Each pen had an open top and sides were made of metal grids (picture 1), cutter shavings were used as substrate, the perches had rounded corners and were 50 cm long and at 15, 30 and 45 cm high. One feed dispenser and four water nipples in each pen (picture 2). The groups with the different hybrids were allocated evenly in the stable. Temperature and humidity was measured twice each day at two sites of the stable. Temperature was 33°C when the chickens arrived and gradually lowered to 23°C during the study.

Picture 1. *Stable with evenly allocated groups.*

Picture 2. *Each pen contained perches, litter and feeding- and drinking dispensers*

Two organic certified feeds were used, one with high protein content and one with low (table 2), for complete nutrient content see Rezaei et al. (2015). Pelleted straw was used as roughage. Consumption of feed and roughage were continuously registered and feed and water daily controlled (ad lib access to water), containers were cleaned twice a week.

Table 2. *Metabolizable energy and crude protein content percent of total content*

Content	High protein feed	Low protein feed
Metabolizable energy (MJ)	11.3	11.2
Crude protein %	17.0	14.5

Recordings

The behaviour and health of the chickens was observed with direct observations at 2, 6 and 9 weeks of age. There were different numbers of chickens at the three occasions (table 3), due to mortality. Long-term behaviours were observed with scan sampling on group level. Social interactions were observed with continuous observations on three focal animals in each group. The observer visited the stable the day before the observations to train the chickens of human presence. Welfare indicators and health registrations was assessed the day after the behavioural observations in order to decrease the risk of effecting the chickens' behaviour when handling them.

Table 3. *Number of chickens at recording*

Hybrid	Week 2		Week 6		Week 9	
	Day 1[1)]	Day 2[2)]	Day 1	Day 2	Day 1	Day 2
Ross	218	216	213	212	198	195
Rowan	209	209	207	207	200	200

[1)] Behavioural observations
[2)] Observations according to the Welfare Quality® Protocol for Poultry

Behaviour recording

Behaviours recorded with scan sampling were standing, sitting, sleeping, perching, eating and drinking and foraging (table 4). At each observation date, there were two one-minute scans on each group with approximately 30 minutes in between the two scans. Behaviours observed with continuous observations were dustbathing, comfortable wing clapping, wing and leg stretch, grooming, perching, flying, running, food running, group running, play fighting, gentle feather pecking, sever feather pecking and aggressive peck. These observations were done for five minutes per group and occasion, on three colour-marked focal animals in each group and by the same person at all ages.

Table 4. *Ethogram for scan and continuous behaviour recording*

Behaviour	Definition	
	Scan	Continuous
Standing	Standing upright with both feet, but no other part of body, on ground	
Sitting	Sitting down with bent legs and abdomen in contact with ground. Head held upright	
Sleeping	Laying on abdomen or side with neck relaxed and eyes shut	
Perching	Standing, sitting or sleeping on any part of the perch	
Eating/ drinking	Manipulating feeding station or drinking nipples with beak	Manipulating feeding station or drinking nipples with beak
Foraging	Manipulating substrate with beak previous or after scratching substrate with feet	Manipulating substrate with beak previous or after scratching substrate with feet
Dustbathing		Vertical wing shakes in a sitting position followed by side- or head-rubs lying on the side, involving motion of the legs
Comfortable wing flapping		Stretching out and flapping wings once or more
Wing/leg stretch		Slowly stretching out one wing and/ or one leg
Grooming		Manipulation of own body with beak
Flying		Flapping of both wings resulting in the entire bird leaving the ground
Running		Bird running for two seconds or more
Food running		Bird running with food, feather, piece of substrate or similar in beak
Group running		Three or more birds running together
Play fighting		Two birds shortly pushing their feet at each other, often coinciding with running
Gentle feather pecking		Manipulation of feathers or beak of other bird
Sever feather pecking		Manipulation of feathers or beak of other bird with detached feather or lesions as consequence
Aggressive pecking		One single peck on other bird, made with force and from above

Welfare and health recording

Traits included in the assessment of welfare and health registrations were; qualitative behaviour assessment (QBA), panting and huddling, litter score, touch test, cleanliness score, FPD score, hock burn score and gait score (table 5). Recordings were made according to descriptions in the Welfare Quality® Assessment protocol for poultry (Algers, 2009) and adapted to the experiments conditions. Measurements were performed by the same person at the three occasions, and done one group at the time.

Table 5. *Measurements applied on 2, 6 and 9 weeks old R and RR broiler hybrids, performed in the described order*

Measurement	Description of the assessment adapted to experiment conditions
Qualitative Behaviour Assessment	Chickens observed from outside the pen, on group level. Scoring emotional states between zero (absence of expression) and 125 (maximum expression) on a 125 mm long visual analogue scale (VAS). Emotions: active, relaxed, comfortable, fearful, agitated, confident, depressed, calm, tense, unsure, energetic, frustrated, bored, friendly, positively occupied, scared, nervous, happy and distressed.
Panting and huddling	Number of chickens panting or huddling was counted from outside of the pen.
Litter quality	Litter quality was assessed by examining it with the foot inside of the pen, scoring on a scale from zero (dry and flaky, moves easily by the foot) to four (compact crust and sticky litter). Observations at the perch site and by the water and feeding area.
Touch Test	Technician sat down inside of the pen reaching out an arm, recording the number of chickens at arms length, and the number of birds actually touched. The trial was repeated twelve times successively in each group.
Cleanliness score[1)]	Group wise, chickens cornered by a grid, technician picked up one chicken at a time scoring the ventral region cleanliness by flipping the chickens on their back. Scoring on a scale from zero (clean) to three (dirty).
Foot Pad Dermatitis score	Each bird in the pen was scored on a scale from zero (absent from lesions) to four (severe lesions) while the chicken was lying on its back.
Hock Burn score	Chicken still lying on its back, hock burns was assessed on a scale from zero (absent) to four (severe).
Gait score	Technician put down the chicken on the other side of the grid, assessing gait score on a scale from zero (normal, dextrous and agile) to five (incapable of walking).

[1)] Cleanliness score, Foot Pad Dermatitis score, Hock Burn score and Gait score was observed in one sequence for each individual chicken. The proportion of birds in the pen with each score was recorded in these measurements

Statistical Analyses

Data editing, preparation of data and result graphs were done in Excel. Statistical analyses were done with the computer program Statistical Analysing Systems (SAS), version 9.3. PROC FREQ and PROC MEANS were used in the descriptive statistical analyses, giving frequency charts, mean values and standard deviations. PROC GLM was used for general linear models to analyse differences between hybrids, providing least square means, standard errors and P-values. Body weight gain was analysed with MODEL 1, MODEL 2 were used for weight variations within groups at slaughter. Percent chickens culled, live weight at slaughter and variables for behaviour and health (see table 4 and 5) were analysed with MODEL 3. Diet included high or low protein treatments, genotype included Ross or Rowan Ranger, genotype and diet interaction were fixed effects, age at weighing a repeated measure and mean weight at slaughter a continuous covariate.

MODEL 1: *y = Diet + Genotype + Diet*Genotype + Age at weighing + e*
MODEL 2: *y = Diet + Genotype + Diet*Genotype + Mean weight at slaughter + e*
MODEL 3: *y = Diet + Genotype + Diet*Genotype + e*

The smallest experimental unit was a group of chickens, 20 in total, 10 replicates of each hybrid. Calculating means on group level for the different variables made it possible to use categorical variables, such as proportion of chickens given each gait-score, as continuous variables. This enabled normal distribution, a condition for the variance analysis. Results of the different feed treatments are not described in this thesis but it was corrected for in the statistical model. There were equal amounts of feed treatments in the two hybrids. The residuals of the parameters in the ANOVA analyses were tested for normal distribution using PROC UNIVARIATE and all were normal distributed with the exception of some data from the continuous observations.

Significance is explained as graded stars in the result part of this thesis, where *= $0.05>p>0.01$, **= $0.01>p>0.001$ and ***= $p<0.001$.

RESULTS

Weight and mortality

Mean weight the day before slaughter was significantly higher for R than RR birds (3986g±50.8g R, 2817g±50.8g RR, LSM±SE, p=**), and mean weight gain/ day was also higher for R (55.4±0.71g R, 38.3±0.52g RR, LSM±SE, p=**) (Rezaei et al., 2015).

In total 40 chickens died or were culled before slaughter, 30 of those had been culled and 10 found dead. Significantly higher proportion of R birds was culled due to leg weakness (10.0±2.00 and 3.3±2.00 % respectively, p=0.031) (Rezaei et al., 2015) (figure 2). One R chicken was culled due to deformity and 2 RR chickens due to illness and escaping out of the pen.

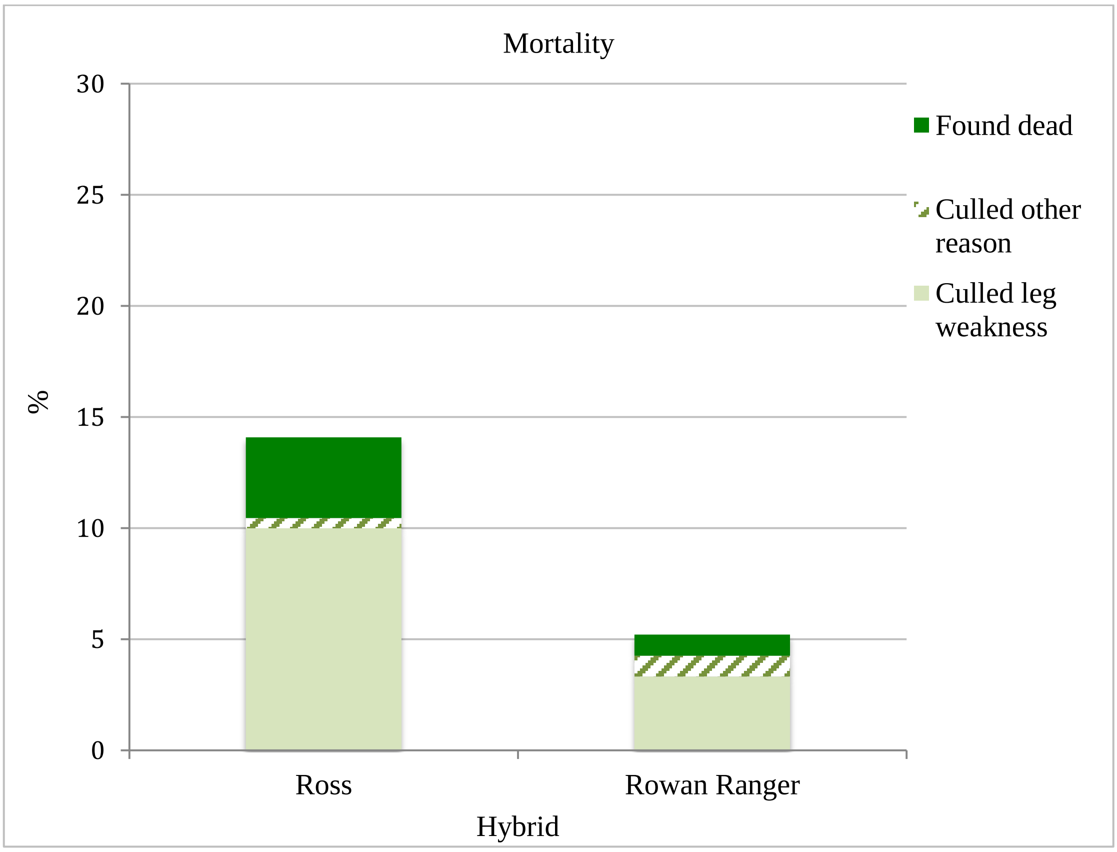

Figure 2. *Percent of the chickens found dead or culled during the experiment, at zero- 70 days of age. In total 429 chickens entered the experiment, 218 R and 211 RR.*

Behavioural data

RR birds spent significantly more time standing (figure 3) and R birds sat more (fig. 4), at 6 and 9 weeks of age. Both hybrids increased the time sitting and decreased time standing with age. A significantly higher percentage of RR used the perches at 6 and 9 weeks of age (figure 5). R ate and drank more often than RR at 2 and 6 weeks, there were no significant difference at 9 weeks of age (figure 6). No significant difference in eating/drinking between the hybrids at 6 weeks of age was found in the continuous tests, in contrast to the scan test. There was no significant difference in time spent sleeping between the two hybrids, both R and RR showed a slight decrease over time.

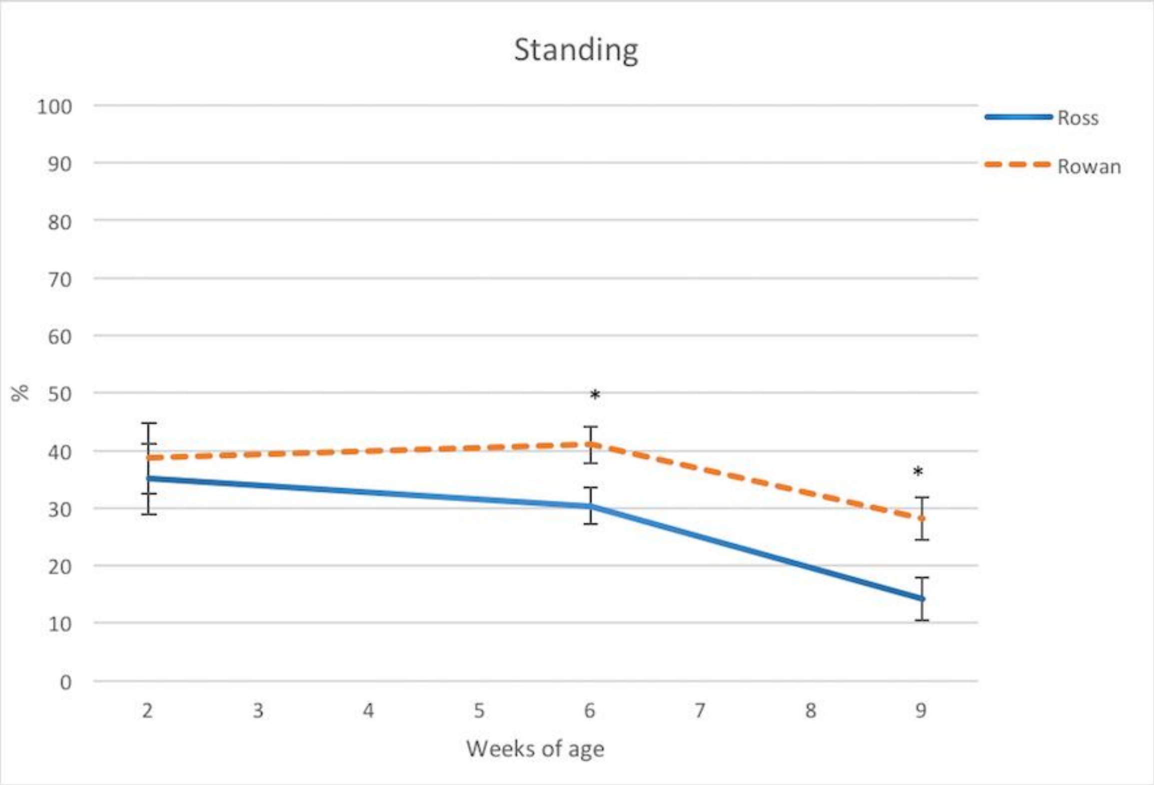

Figure 3. *Percent of the chickens standing at 2, 6 and 9 weeks of age. LSM, SE and significance in graph. Number of chickens at 2 weeks; 218 R and 209 RR, 6 weeks; 213 R and 207 RR and 9 weeks; 198 R and 200 RR.*

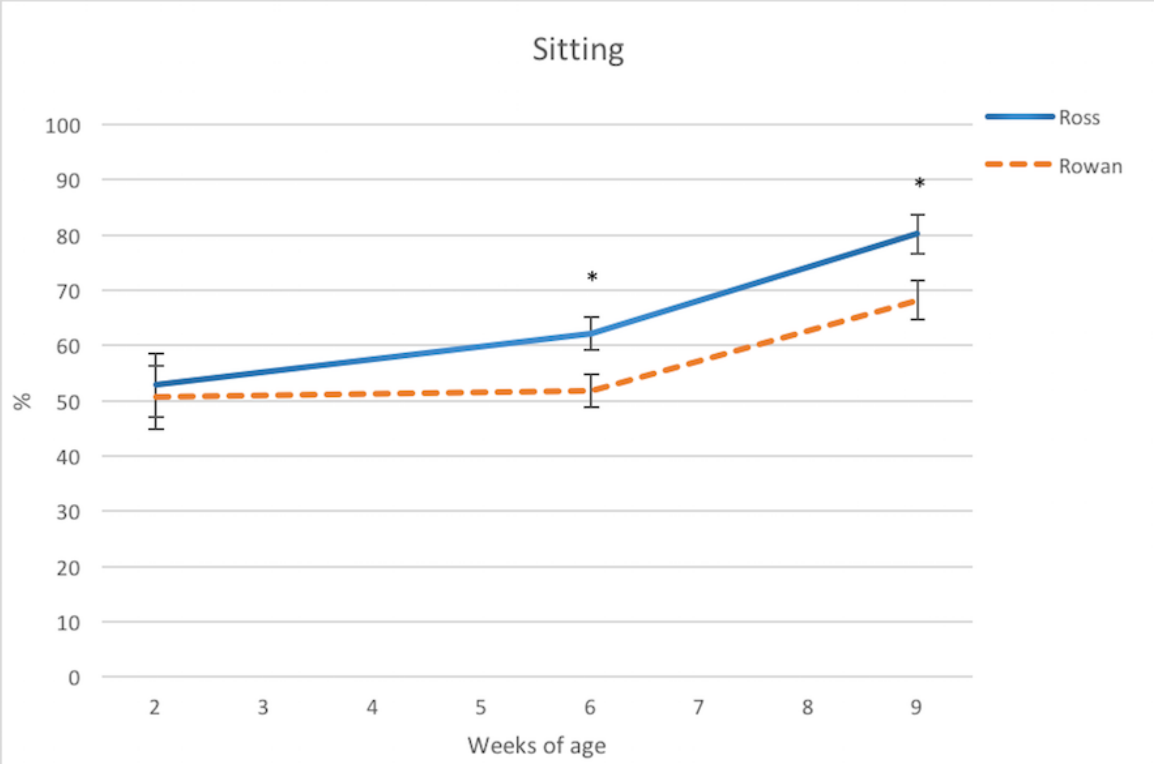

Figure 4. *Percent of the chickens sitting at 2, 6 and 9 weeks of age. LSM, SE and significance in graph. Nr. of chickens at 2 weeks; 218 R, 209 RR, 6 weeks; 213 R, 207 RR and 9 weeks; 198 R, 200 RR.*

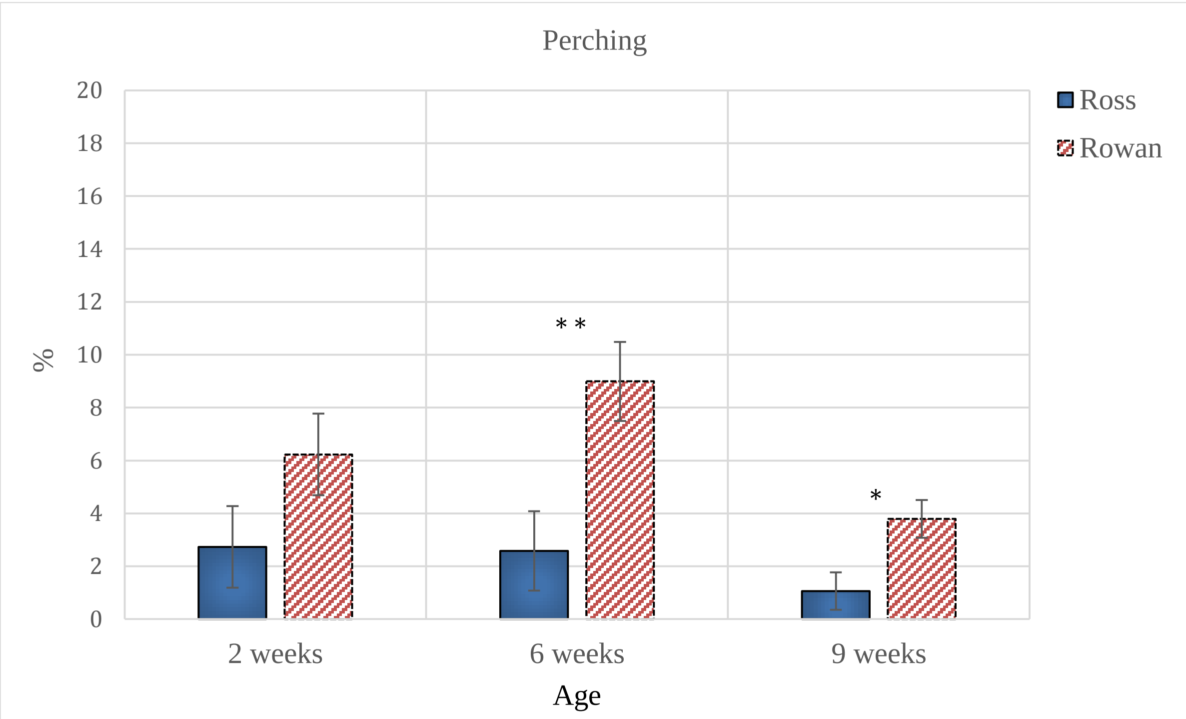

Figure 5. *Percent of the birds perching at 2, 6 and 9 weeks of age. LSM, SE and significance in graph. Nr. of chickens at 2 weeks; 218 R, 209 RR, 6 weeks; 213 R, 207 RR and 9 weeks; 198 R, 200 RR.*

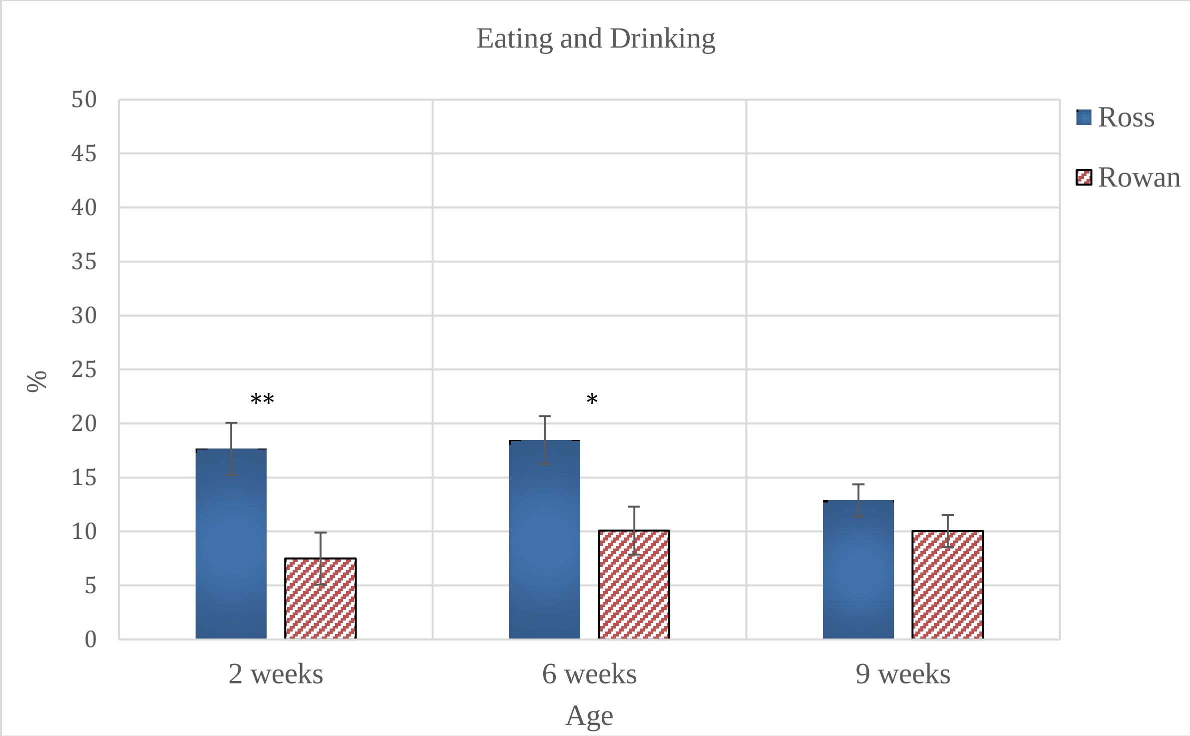

Figure 6. *Percent of the birds eating and drinking at 2, 6 and 9 weeks of age. LSM, SE and significance in graph. Nr. of chickens at 2 weeks; 218 R, 209 RR, 6 weeks; 213 R, 207 RR and 9 weeks; 198 R, 200 RR.*

Foraging behaviour decreased with age in R chickens, and peaked at 6 weeks in RR before decreasing (figure 7). RR showed significantly higher values (P= 0.03) than Ross at 9 weeks of age. There were no significant differences found between the hybrids in the other behaviours measured with continuous observations, and the result is therefor presented with descriptive statistics (table 6). RR showed a bit higher (numerical) prevalence of comfort behaviours such as comfortable wing clap. Dustbathing, flying, food running, group running, severe feather pecking, aggressive pecking and other behaviours was never observed in the continuous observations.

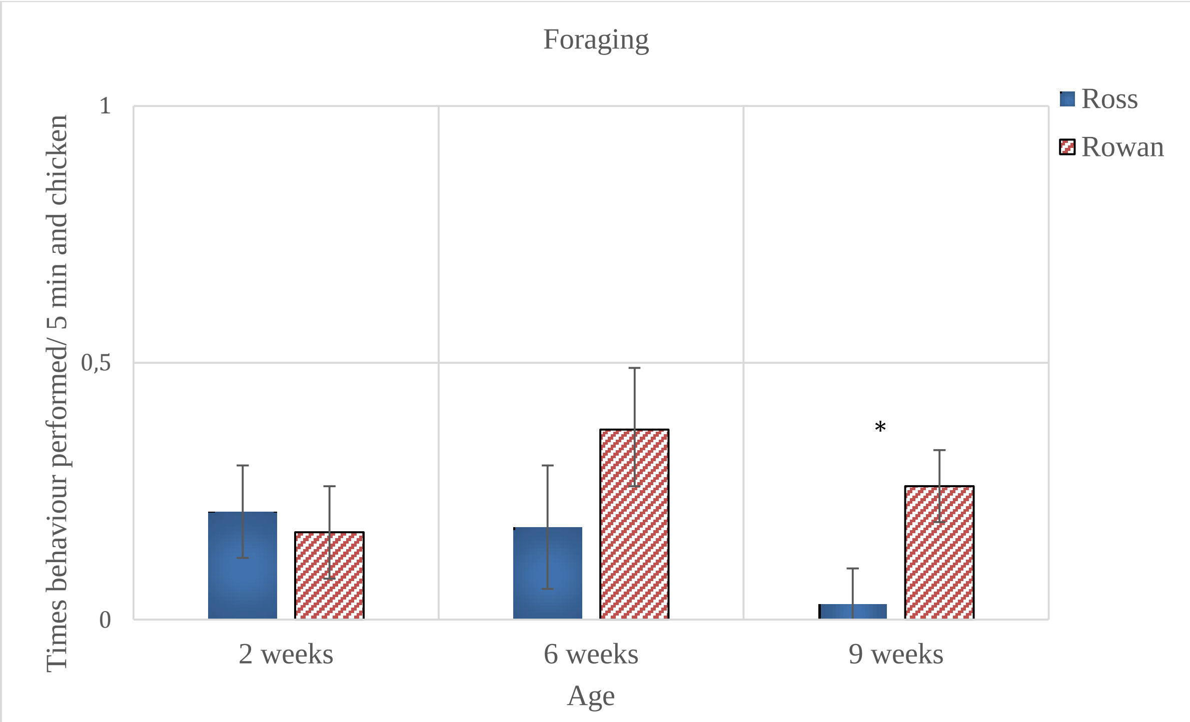

Figure 7. *Mean values of times the chickens performed foraging behaviour per 5 min and chicken. At 2, 6 and 9 weeks of age, on three focal animals in each group. LSM, SE and significance in graph. Nr. of chickens at 2 weeks; 218 R, 209 RR, 6 weeks; 213 R, 207 RR and 9 weeks; 198 R, 200 RR.*

Table 6. *Descriptive statistics of behaviours measured with continuous observations on 3 focal animals in each group (10 groups per hybrid), times behaviour was performed/ bird and 5 minutes*

Behaviour	Mean value (min-max)	
	Ross	Rowan
Comfortable wing clap	0.12 (0-1.33) [1)]	0.17 (0-0.66)
Wing and leg stretch	0.32 (0-1.66)	0.34 (0-1.66)
Grooming	0.6 (0-2.66)	0.8 (0-2.33)
Perching	0.09 (0-0.66)	0.24 (0-1.66)
Running	0.01 (0-0.33)	0.08 (0-1)
Play fighting	0.02 (0-0.33)	0.04 (0-1)
Gentle feather pecking	0.08 (0-0.66)	0.19 (0-0.66)

[1)] Total mean values for all observations dates, with minimum and maximum values

Welfare Quality assessment results

Health

R chickens showed signs of impaired gait at 2 weeks of age, there were significant differences in gait at 2, 6 and 9 weeks of age. Both hybrids showed signs of impaired walking ability at 6 and 9 weeks of age (table 7). There were significant differences between R and RR in foot pad dermatitis at 6 and 9 weeks of age (table 8). Hock burns were absent in both hybrids at 2 and 6 weeks of age, at 9 weeks of age many of the R chickens showed signs of more developed hock burns (figure 8).

Table 7. *Percent of the chickens with gait score 0, 1, 2, 3, 4 and 5 (normal gait, slight abnormal gait, identifiable abnormality, obvious abnormality, severe abnormality and incapable of walking) at 2, 6 and 9 weeks of age. LSM, SE and significance in table. Nr. of chickens at 2 weeks; 216 R, 209 RR, 6 weeks; 212 R, 207 RR and 9 weeks; 195 R, 200 RR*

	2 weeks			6 weeks			9 weeks		
Score	Ross	Rowan	P-value	Ross	Rowan	P-value	Ross	Rowan	P-value
0	96±0.8[1)]	100±0.8	**	68±2.4	96±2.6	***	7±2.9	36±2.9	***
1	4±0.8	0±0.8	**	26±1.7	4±1.8	***	13±3.5	45±3.5	***
2	0±0	0±0	n.s.	4±1.3	0±1.4	*	36±1.6	18±1.6	***
3	0±0	0±0	n.s.	0.5±0.4	0±0.4	n.s.	36±3.1	2±3.1	***
4	0±0	0±0	n.s.	0.5±0.4	0±0.4	n.s.	6±1.8	0±1.8	*
5	0±0	0±0	n.s.	0.5±0.4	0±0.4	n.s.	2±0.9	0±0.9	n.s.

[1)] Least square means ± standard error

Table 8. *Percent of the chickens with Foot Pad Dermatitis score 0, 1, 2, 3 and 4 (0= absent, 4= severe) at 2, 6 and 9 weeks of age. LSM, SE and significance in table. Nr. of chickens at 2 weeks; 216 R, 209 RR, 6 weeks; 212 R, 207 RR and 9 weeks; 195 R, 200 RR*

	2 weeks			6 weeks			9 weeks		
Score	Ross	Rowan	P-value	Ross	Rowan	P-value	Ross	Rowan	P-value
0	93±1.9[1)]	92±2	n.s.	65±3.6	93±3.7	***	42±6.7	74±6.9	**
1	7±1.9	8±2	n.s.	29±3	7±3	***	52±5.4	23±5.4	**
2	0±0	0±0	n.s.	6±1.4	0±1.4	**	6±2	3±2	n.s.
3	0±0	0±0	n.s.	0±0	0±0	n.s.	0±0	0±0	n.s.
4	0±0	0±0	n.s.	0±0	0±0	n.s.	0±0	0±0	n.s.

[1)] Least square means ± standard error

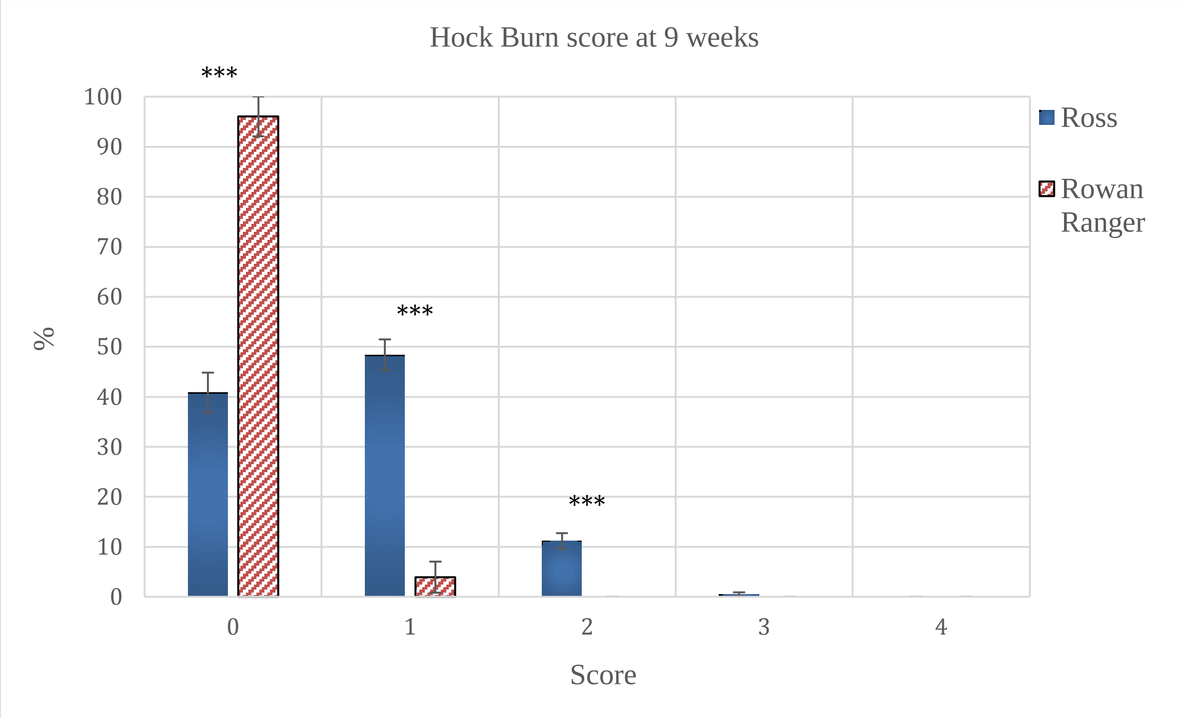

Figure 8. *Percent of the chickens with hock burn score 0, 1, 2, 3 and 4 (0= absent, 4= severe) at 9 weeks of age. LSM, SE and significance in graph. Nr. of chickens; 195 R, 200 RR.*

Housing

There were significant differences in plumage cleanliness between the hybrids at 2, 6 and 9 weeks of age (table 9). Approximately 90 % of RR scored zero at 2 weeks of age. Considerably less chickens (both R and RR) scored zero at week 9, about 80% of R scored 2 or 3 at that point. There were clear differences in litter quality between the hybrids at 6 and 9 weeks of age, groups with R chickens got higher scores indicating wetter litter (figure 9). Analyses showed differences between the hybrids in thermal comfort, R chickens were panting significantly more than RR at 2 and 9 weeks of age (figure 10). RR chickens were huddling significantly more than Rowan at 9 weeks of age (figure 11). Mean temperature and relative humidity in the stable was 26.4 °C and 33.5% at 2 weeks, 23.9 °C and 43.4 % at 6 weeks and 23.2 °C and 61.3 % at 9 weeks.

Table 9. *Percent of the chickens with cleanliness score 0, 1, 2 and 3 (0= clean, 3= dirty) at 2, 6 and 9 weeks of age. LSM, SE and significance in table. Nr. of chickens at 2 weeks; 216 R, 209 RR, 6 weeks; 212 R, 207 RR and 9 weeks; 195 R, 200 RR*

	2 weeks			6 weeks			9 weeks		
Score	Ross	Rowan	P-value	Ross	Rowan	P-value	Ross	Rowan	P-value
0	77±3.6[1)]	89±3.6	*	69±3.7	96±3.7	***	1±2.4	21±2.4	***
1	23±3.6	11±3.6	*	26±2.9	4±2.9	***	19±3.9	65±3.9	***
2	0±0	0±0	n.s.	5±1.5	0±1.5	*	51±3.1	13±3.1	***
3	0±0	0±0	n.s.	0±0	0±0	n.s.	29±3.5	1±3.5	***

[1)] Least square means ± standard error

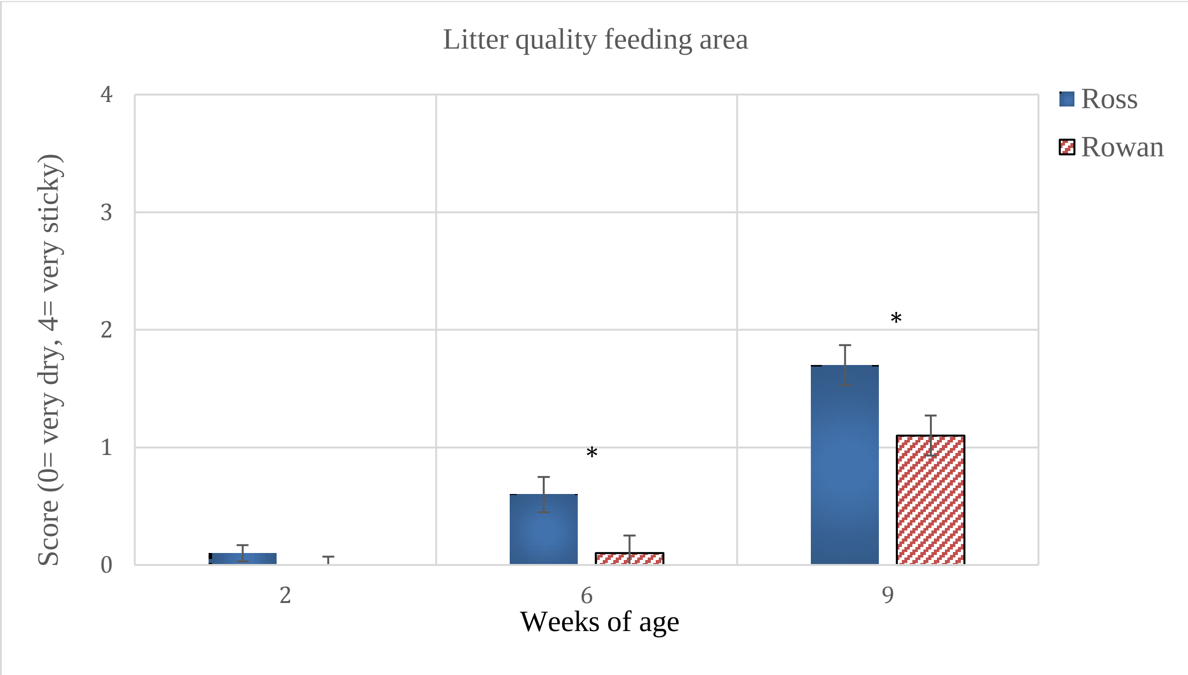

Figure 9. *Mean values of the litter quality scores at the feeding area at 2, 6 and 9 weeks of age. LSM, SE and significance in graph. Nr. of chickens at 2 weeks; 216 R, 209 RR, 6 weeks; 212 R, 207 RR and 9 weeks; 195 R, 200 RR.*

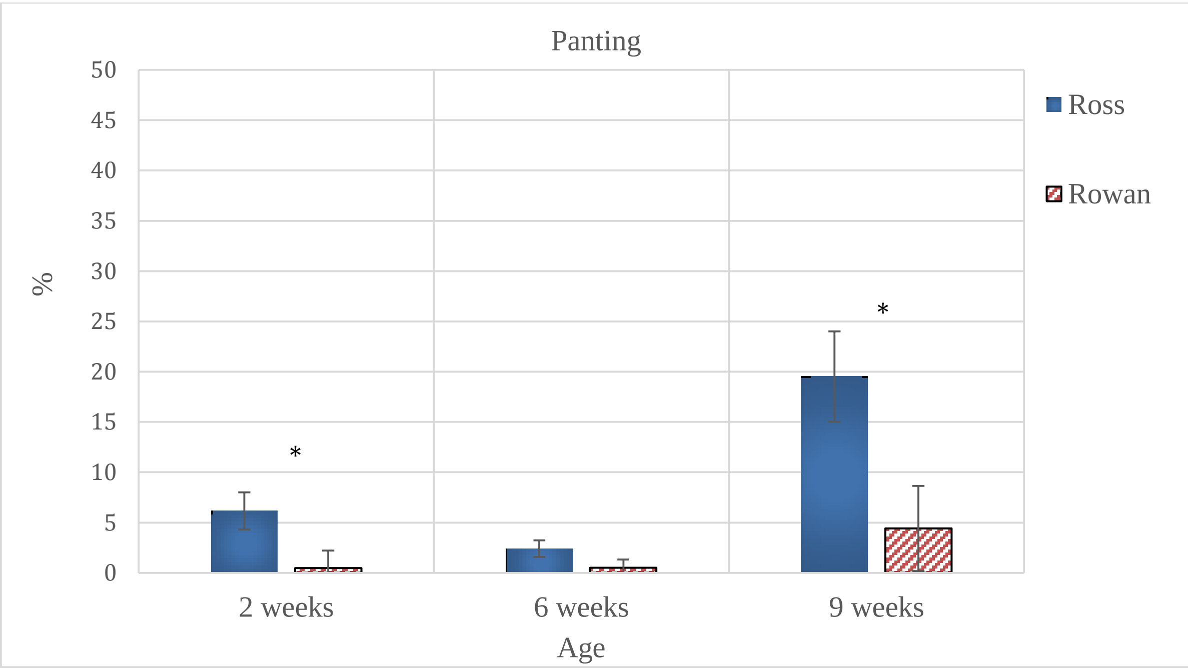

Figure 10. *Percent of the birds panting at 2, 6 and 9 weeks of age. LSM, SE and significance in graph. Nr. of chickens at 2 weeks; 216 R, 209 RR, 6 weeks; 212 R, 207 RR and 9 weeks; 195 R, 200 RR.*

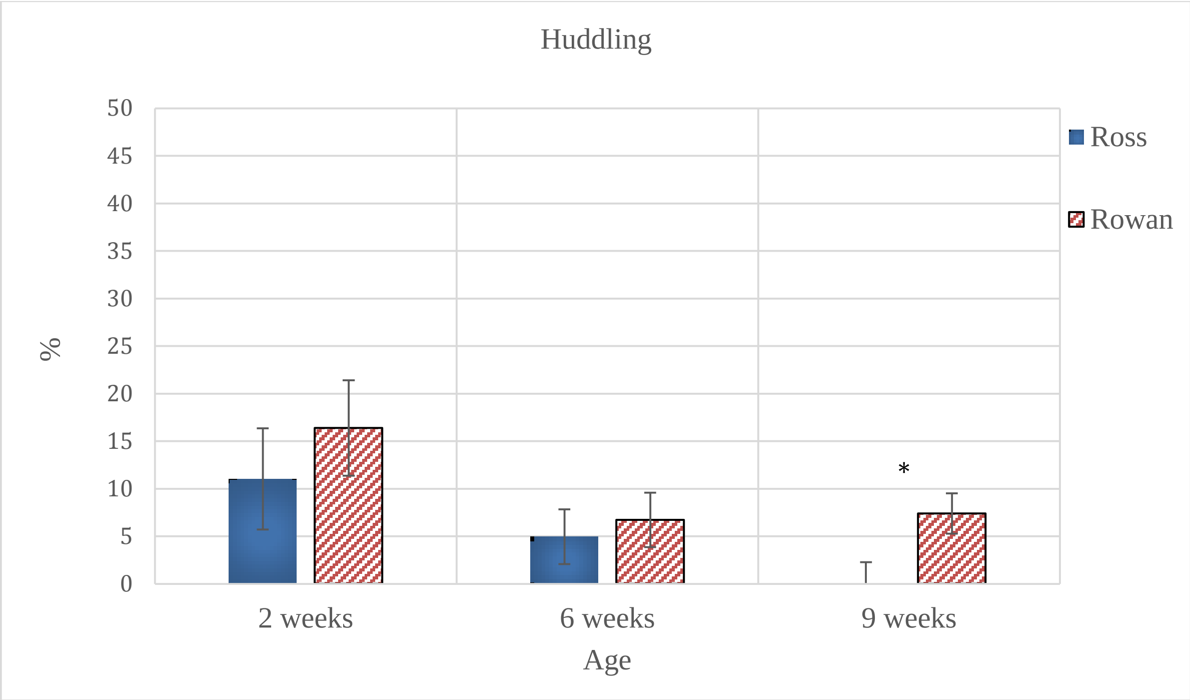

Figure 11. *Percent of the birds huddling at 2, 6 and 9 weeks of age. LSM, SE and significance and in graph. Nr. of chickens at 2 weeks; 216 R, 209 RR, 6 weeks; 212 R, 207 RR and 9 weeks; 195 R, 200 RR.*

Touch test and QBA

The touch test showed significantly higher values for R than RR at all ages, i.e. more R chickens were touched at arms length (figure 12). Positive and negative emotional states evaluated with QBA showed no difference in activity during the first weeks, however RR chickens were more active than R at 9 weeks of age (P=0.01). There were significantly higher values in positive states in R and more expressed negative emotional states in RR chickens at 2 weeks of age (figure 13). Significantly higher values in some negative states in RR at 6 weeks of age, otherwise no significant differences between the hybrids at that age (figure 14). At 9 weeks of age, RR showed significantly more expressions of positive emotional states and R expressed emotions such as calm and bored to a larger extent (figure 15).

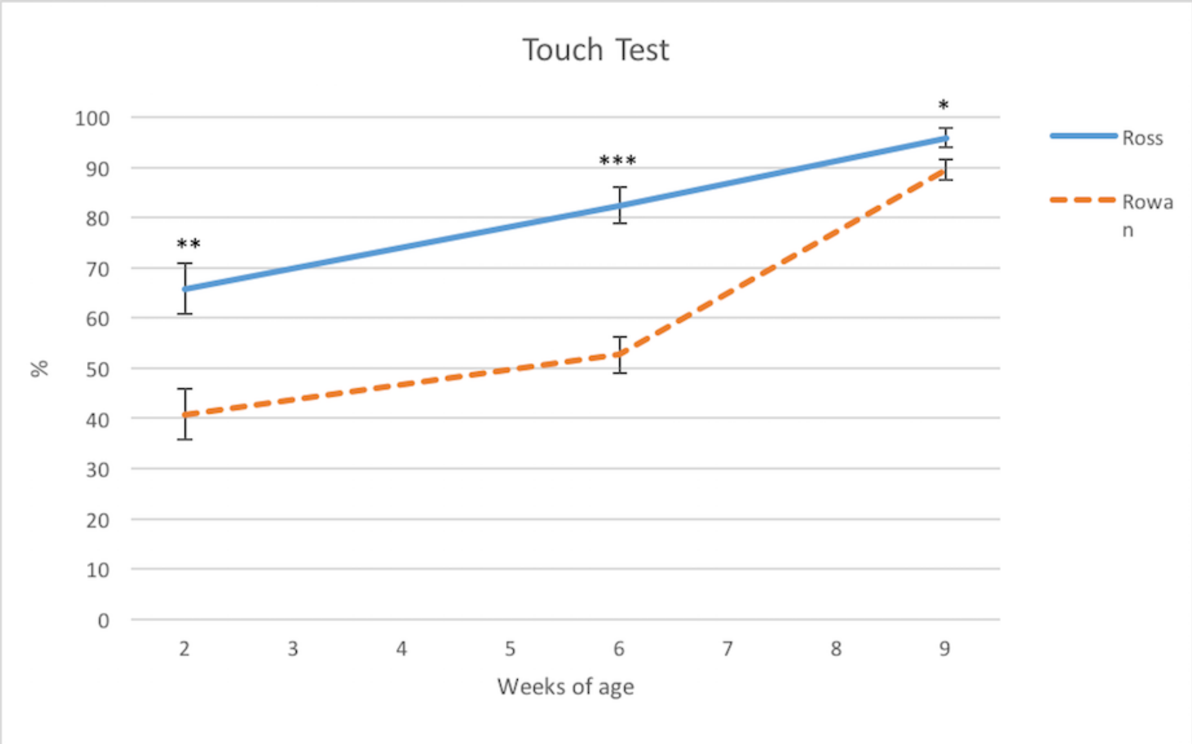

Figure 12. *Percent of the birds touched at arms length distance, at 2, 6 and 9 weeks of age. LSM, SE and significance in graph. Nr. of chickens at 2 weeks; 216 R, 209 RR, 6 weeks; 212 R, 207 RR and 9 weeks; 195 R, 200 RR.*

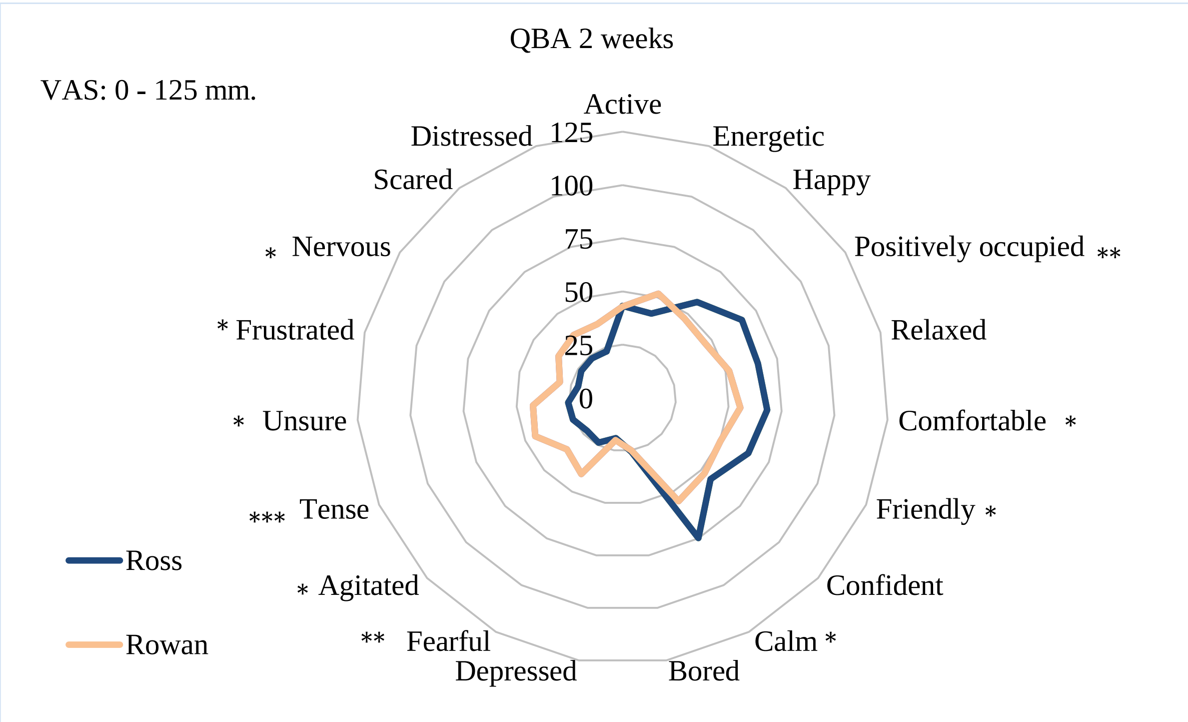

Figure 13. *Qualitative Behaviour Assessment of R and RR at 2 weeks of age. The length from minimum left point to marking on the VAS (scale). LSM and Significance in graph. Nr. of chickens; 216 R, 209 RR.*

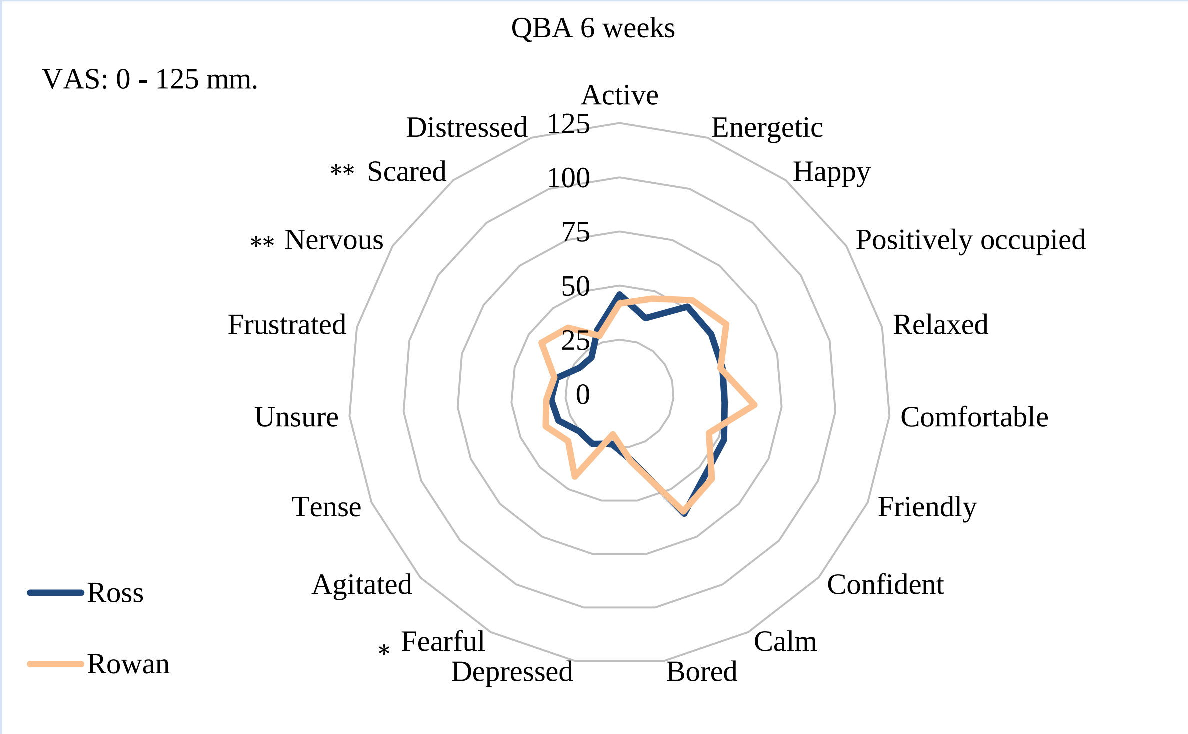

Figure 14. *Qualitative Behaviour Assessment of R and RR at 6 weeks of age. The length from minimum left point to marking on the VAS (scale). LSM and Significance in graph. Nr. of chickens; 212 R, 207 RR.*

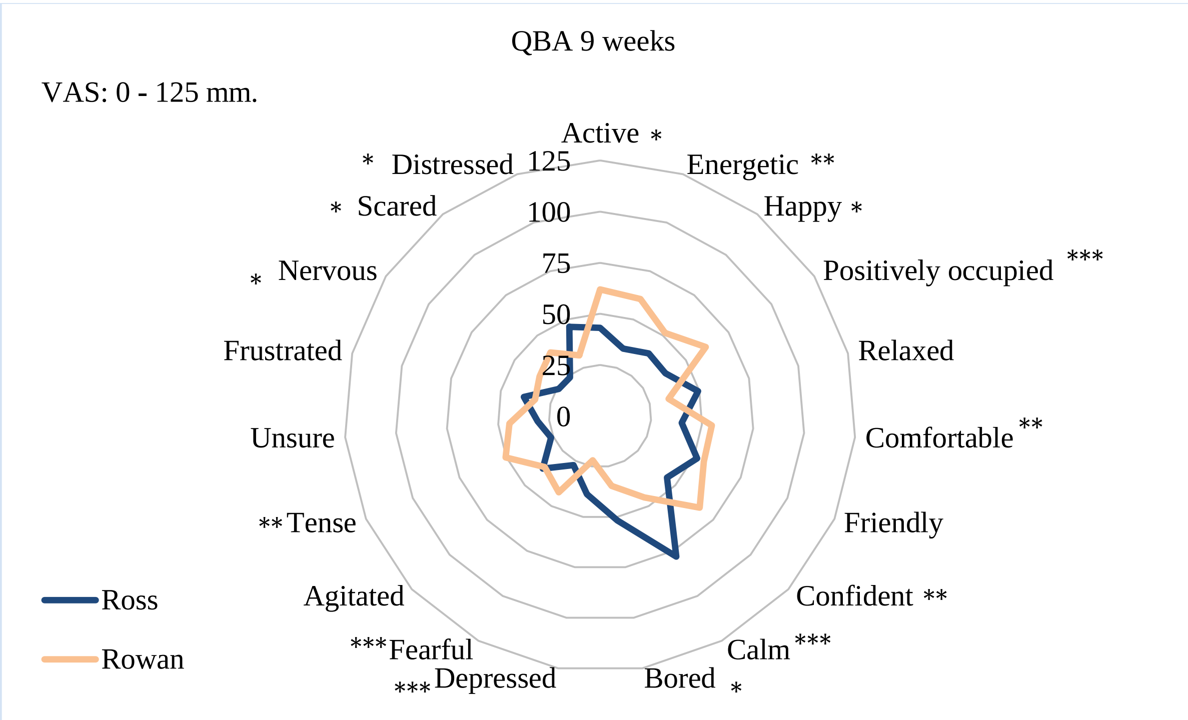

Figure 15. *Qualitative Behaviour Assessment of R and RR at 9 week of ages. The length from minimum left point to marking on the VAS (scale). LSM and Significance in graph. Nr. of chickens; 195 R, 200 RR.*

DISCUSSION

The overall aim of this thesis was to quantify differences in behaviour and health between two broiler hybrids with different growth rate. Interest in this field of subject originates from the fact that one of the reasons for the scarce OB production in Sweden has been lack of hybrids suitable for the production system (Jordbruksverket, 2013) and the absence of a national breeding program (Nielsen et al., 2003, Bassler, 2008). The results in this project suggest that FG broilers are not suited for OB production as they suffer from severe leg problems when long rearing periods are applied, as supported by the earlier findings reported in Castellini et al. (2002). FG broilers are not able to make as much use of environmental enrichment as SG broilers. Instead of restricting the growth potential of FG chickens, using slower growing hybrids such as Rowan Ranger would increase chicken welfare in these production systems and it would be a efficient way to decrease prevalence of diseases (Bessei, 2006).

Summary of the results

To summarise findings, mean weight at slaughter was higher for R birds and differed with about 1.2 kg between the hybrids. Leg weakness was more common in R, leading to a three-fold higher culling rate for that hybrid. Activity decreased and health was impaired with age in both hybrids but at a later age in RR than in R. Both hybrids sat more with increased age and even though RR showed higher prevalence of standing and perching, their activity decreased as well after six weeks of age. R birds spent more time eating and drinking than RR at two and six weeks of age, while prevalence of foraging behaviour was low in both hybrids. Many of the social interactions studied using continuous observations were never observed during the observation sessions, i.e. were uncommon. Regarding health, R showed significantly worse gait at all ages, however only 36 % of RR scored zero at nine weeks, indicating leg problems even if less than in R. Also for FPD, both hybrids were afflicted at six and nine weeks with R showing higher prevalence than RR. There were very little signs of HB in RR, while more than half of R birds scored 1 or 2 at nine weeks of age, probably connected to lower litter quality and activity in R groups. R scored higher than RR in cleanliness at all ages and litter quality at two and six weeks (seen as dirtier plumage and more humid litter). Additionally, R was panting more at nine weeks, possibly indicating thermal stress. Fewer RR birds were touched in the TT and they were assessed to be more nervous and fearful than R in the qualitative behaviour assessment, however additional measurements would be needed in order to discuss any differences in fear.

Methodological aspects

As a part of a larger project this study focused on both behaviour and health in two broiler hybrids, however, due to size and time recommendations for a master thesis, some limitations were imposed. To start with, no correlations between different measurements was made, this could have given a more comprehensive picture. For example, the potential correlation between contact dermatitis, gait score and weight could have been analysed. When comparing these results with results from previous studies, it is necessary to consider that hybrids other than R and RR could be referred to as fast- and slow-growing. Furthermore, RR could be called a medium-growing or even fast growing hybrid if compared to slower growing meat type chickens or dual-purpose breeds available in other countries. Therefore, it would be questionable to directly compare results in different studies, unless the same hybrids have been used.

Measurements done according to the welfare quality protocol worked well in most cases. The QBA results add some knowledge of how humans interpret the emotional state in chickens, but it is difficult to draw any further conclusions. Measuring fear is complex and it would have been necessary to involve additional measurements to the touch test, such as heart rate or stress hormones (Zulkifli and Azah, 2004), in order to estimate if fear of human differed between the hybrids, and how much the decreased locomotor activity influenced the behaviour (Waiblinger et al., 2006). Cransberg et al. (2000) explained that very young chicks are susceptible of human behaviour and recordings of way of handling and walking pace in the stable might also have made it easier to analyse the fear-responses. However, vision of humans at an early age can decrease stress in chickens (Zulkifli and Azah, 2004) and due to a relatively small number of animals in each group, most likely all chickens in this experiment got vision of technicians regularly. Scan test of behaviours connected to time budget worked well, but the continuous observations of social interaction may have gained from a longer observation time than 5 min per group since very few observations were made. Number of focal animals observed and time of the day could have influenced results as well. Of course, a rare occurrence of these behaviours may explain the results.

The possible conclusions made from this study are more applicable for the OB production in Sweden than previous similar studies in other countries regarding available hybrids, feed content and space allowance. However, the chickens were slaughtered at 70 days instead of 81 and were not offered outside space, which is required in the Swedish OB production.

Health

Due to KRAV, FG broilers must not grow more than 50 g/ day (KRAV, 2015b), something that requires feed restriction or low protein content in feed for FG broilers. Mean value for gained growth/ day was about 5 grams too high in R birds and well below 50 g in RR birds. This was regardless of the two different feed treatments (Rezaei et al., 2015).

R had an overall higher mortality and 10 % were culled du to leg weakness compared to 3 % in RR. These results are in accordance with previous findings in Castellini et al. (2002) who also describes high culling rates and leg weakness in R birds. The fact that lame birds were culled throughout the experiment affects the results for gait score as those birds who would have been scored with high figures was removed. At nine weeks of age, the majority of R birds were scored two or three in gait, whilst most of RR were scored zero to one. This is in accordance with Kestin et al. (1999) who found that lameness is influenced by a high live and growth rate, when comparing several FG and SG genotypes. The results of a deteriorating gait after 6 weeks of age in RR birds are interesting when assessing their suitability in a production system where slaughter is at 81 days. However, the differences between the hybrids are notable, 2 % of RR birds and 36 % of R scored three in gait at nine weeks. 15 years ago, Weeks et al. (2000) found that sound FG broilers (not lame) spent an average of 76% lying down, increasing to 86% in lame birds with gate score 3. Even though no correlation between GS and time spent sitting have been analysed in this study, there are clear results of both decreased activity and increased GS (worse gait) together with higher age and weight in R chickens. Similar results are described in several studies under both conventional (Reiter, 2006, Naas et al., 2009, Corr et al., 2003) and organic (Nielsen et al., 2003) rearing conditions. However, Sherlock et al. (2010) found no correlation between activity and leg health, e.g. gait and hock burn in FG broilers (R), suggesting that the these chickens do not exercise sufficiently which hamper increase in bone quality and that the passivity could be linked to body conformation, effecting the gait. Even though RR chickens scored lower than R at all ages, their gait also deteriorated after six weeks, something that is notable since their activity (standing) and behaviours connected to activity, such as foraging, peaked at six weeks and then declined. These results suggest that the welfare of both R and RR chickens are questionable in the end of the rearing period in OB production.

R birds had higher prevalence of FPD at two and nine weeks of age than RR (table 7), and more severe HB at nine weeks (fig. 9). One possible explanation is poor litter quality, as explained by Bessei (2006), since it was more humid in R groups at corresponding ages. However, not only management factors cause contact dermatitis, Kestin et al. (2001) and Kjaer et al. (2006) found differences between hybrids, conformable with findings in the present study, and suggests that FPD may be affected by genotype and that genetic selection could decrease susceptibility without effecting productivity traits. Perhaps, there could be differences between the hybrids used in this study regarding both behaviour and physical traits such as skin thickness due to genotype.

Housing

In addition to causing contact dermatitis, inadequate litter quality affect cleanliness, gait and production performance (de Jong et al., 2014), therefore it is interesting to reflect on the possible genotypic variations between R and RR regarding impact on litter. One potential factor that may explain why litter quality was lower in R groups at six and nine weeks was their low activity, maybe by choosing to stay close to feed and water causing increased soiling and litter moisture in that area. Further, R birds had significantly dirtier plumage early on, differences in cleanliness were seen from two weeks of age, also possibly due to decreased activity and spending more time sitting than RR. Another possible explanation could be a higher feed intake in R than RR birds, which would increase soiling and thereby affect litter quality and in turn cleanliness. Ventilation and humidity was measured and in accordance with recommendations and is not likely to have effected litter quality.

Just below 20 % of R birds were panting at nine weeks, significantly more than RR. This result might indicate that R chickens do not cope as well with recommended temperatures at the end of the rearing period as RR, possibly due to differences in body temperature adjustment as suggested by Nielsen (2012). Heat production increase with higher rate of metabolism as well as with increased live weight and this is probably one reason for the increase in panting in R chickens. Due to the increased heat production at the later stages of the growing period, Aviagen (2014b) recommends to keep ambient temperatures below 21°C for FG broilers older than 21 days to avoid growth rate to stagnate. The temperature measured in this study was 23°C at the end of the experiment, and possibly not within the thermal comfort zone in R chickens. Domestication have reduced animals' sensitivity to environmental changes in general, but the qualitative responses still remain (Price, 1999), the rapid growth in R chickens may negatively affect their possibilities to adapt to the ambient temperature. In nature, young chickens are dependent on the protection and warmth of the mother hen and gradually with age spend longer time in colder temperatures when foraging. Perhaps it would be possible to increase welfare by imitating this in a production system, offering different temperature zones in different "eat or sleep" areas of the stable. Experiments done with dark brooders as a substitute of the broody hen on layer hen chicks have shown results of reduced mortality (Jensen et al., 2006, Riber et al., 2007).

Behaviour

Studies on enrichment show that a complex environment give young chickens better qualifications to cope with future stress (Altan et al., 2013), it may also contribute to increased activity in chickens (Bessei, 2006). However results in this study indicate decreased activity for R and RR at older ages (fig. 4), this in accordance with previous findings where activity in FG broilers decreases with age even though enrichment is provided (Jiao et al., 2014). It seems that activity decrease with age in FG broilers even when given the possibility to perform different behaviours. Weeks et al. (1994) and Bokkers and Koene (2003) compared R chickens in different environments and concluded that they are most likely motivated to perform for example perching behaviour, but are prevented by the high growth rate. The decrease of activity such as standing and perching (fig. 4 and 6) in RR chickens at nine weeks of age might indicate that they too are influenced by high weights. Further, compared to the Red Junglefowl, domesticated chickens devote less time to behaviours such as social interactions that cost much energy, likely an effect of selection for production traits (Schutz and Jensen, 2001). The reason for a decreasing activity and low occurrence of social interactions in both R and RR in this study is presumably multifactorial. With increased age, more energy was probably spent on growth and less on behaviours. The environment (e.g. temperature) and genotype (changed gravity due to short legs and large breast muscles (Corr et al., 2003)) were most likely contributing factors. Furthermore, as weight increased with age in both R and RR, their physical ability probably became the dominant determinative factor for activity instead of motivation (Bokkers and Koene, 2004).

Dustbathing was not observed in this study, and even if methodology regarding continuous measurements might need improvement as mentioned earlier, previous research also shows low figures for social and wellbeing behaviours in broilers. Murphy and Preston (1988) observed 19 focal animals, one hour per bird in the middle of the day, without witnessing any dustbathing. Not surprisingly they explained this to be caused by the fast growth rate. Low occurrence of dustbathing might also be an effect of poor litter quality and type of substrate. Broilers seem to perform behaviours, such as dustbathing, to a larger extent in sand than in wood shavings (Toghyani et al., 2010, Shields et al., 2004).

Different needs for rest might be the reason for difference in time spent sitting or standing between R and RR, however there was no difference in time spent sleeping between the hybrids. On the contrary Bokkers and Koene (2003) compared two other FG and SG broiler hybrids and found similar resting times (defined as sitting idle or lying) between them even though the SG hybrid weighed half as much as the FG, and explained it having a genetic background. RR spent more time standing than R, this might be due to better leg health as shown by the better gait score; Weeks et al. (2000) found a correlation in time spent lying down with age and lameness in R chickens. Except the difference between the hybrids in standing, there was an accompanied tendency where both hybrids decreased occurrence of standing from six weeks of age, likely due to genetic factors and increased weight in both R and RR.

Perching is a natural behaviour starting at about two weeks of age, at six weeks of age daytime perching seem to peak (Heikkilä et al., 2006). RR perched more than R at six and nine weeks of age, probably due to the heavier body weight in R chickens. Estevez et al. (2002) found FG broiler males to perch less than females due to higher weight and Bokkers and Koene (2003) found negative correlation between body weight and perching from nine weeks of age in FG (HI-Y, Hubbard ISA) and twelve weeks in SG (JA 657, Hubbard ISA) broilers. Even though different hybrids are used in the mentioned studies, and the age when a decrease of the behaviour occurs varies, the tendency is similar. Also foraging behaviour drastically decrease in R chickens between six and nine weeks while RR chickens seem to carry out a more continuous forage behaviour (fig. 8), significantly more than R at week nine, possibly indicating a better capacity to utilize an outdoor run in OB production.

Interpretation of the touch test result, where significantly more R than RR birds were touched at arms length, would have gained from additional measurements, as previously discussed in this thesis and described by Zulkifli and Azah (2004), since it probably is influenced by restriction of the motor activity in FG chickens. This inference passes for results from the QBA as well, which indicated RR birds to be more nervous and R birds to be calmer. It is not possible to compare these results between hybrids with different growth rate without further measurements to rule out any possible physiological constraints, since SG chickens probably are able to express more energy demanding behaviours at older ages and are not restricted by their weight to the same extent as FG chickens. Conclusions of differences in fear or emotional state between R and RR are therefor not possible in this thesis.

Ethical aspects

The development of broiler production and increase in growth rate in FG broilers is quite remarkable and along with an increased consumption of chicken meat there are more than 60 billion meat type chickens produced annually in the world. The large numbers of birds kept together in intensive production makes it hard to ensure the welfare of each individual. High weights and leg weakness, making them inactive and possibly even appear docile or deceptively calm, therefor puts a lot of animals well being at stake. Appleby et al. (2014) argued that increased attention to each individual improves animal welfare and that this is affected by body- and group size, longevity and price the farmer get along with amount products consumed by people. The mentioned factors indicate that it is more likely that a veal calf has good welfare than a chicken. There is also an aspect of if and how humans relate to animals and if there is a difference in the ability to feel empathy with other mammals compared to birds.

It is worth considering that the welfare of RR chickens might be influenced by fast growth rate and a thereby modification of behaviours, due to resource allocation as described by Schutz and Jensen (2001), to such extent that they can not fully benefit from additional values provided in OB production. It could be argued that any chicken, and specifically more slow growing hybrids, should maintain active and healthy longer than nine weeks of age.

Conclusions

There are differences in behaviour and health between R and RR chickens. The hypothesis that the slower growing RR chickens would be more active and stand and perch more while R sit and eat more was confirmed, probably due to higher live weight and growth rate in R. However, there were no difference in sleeping and social and comfort behaviours as predicted. Some of the behaviours such as dustbathing were never registered, presumably due to low occurrence as a result of selection for production traits reducing energy demanding behaviours.

The hypothesis that FG broilers would have poorer health was confirmed; R chickens scored higher than RR in gait score, FPD and HB and a higher number of R birds was culled due to leg weakness. The health condition in R chickens is probably connected to their high growth rate and live weight, along with decreased activity and possibly also body conformation. RR chickens showed signs of deteriorated gait and contact dermatitis as well as leg weakness but less severe and at older ages, but still, not unaffected.

As predicted RR chickens had cleaner plumage and better litter quality than R, presumably due to higher activity decreasing the time laying on the litter along with possible lower feed consumption (lower eating frequency seen in this study) and thereby less soiling. R chickens seemed to be more affected by temperature and were panting more, probably due to higher metabolic rates and subsequent increase in heat production.

The touch test showed higher levels of fear in RR chickens, as expected, and RR expressed more nervous emotional states while R chickens seemed calmer in the QBA. However, additional measurements would be needed in order to exclude the physiological impact and no conclusions in difference between the hybrids can be made from this study.

The fast growth rate of Ross chickens seems to negatively influence their natural behaviour and health, which does not correspond well with organic ethical production values. Rowan Ranger chickens seem to fit the regulations of organic broiler production in Sweden, regarding growth rate, health and activity, better than Ross chickens. However, despite quite clear differences between the two hybrids in this study, the health and activity in Rowan Ranger chickens also decreased with age even if it was a bit later on than for Ross and not quite to the same extent.

Future research

Further research is needed to gain knowledge of how Rowan Ranger chickens cope with outside areas and if their health status keeps decreasing at even older ages than investigated in this study. How different ambient temperatures effect fast and slow-growing hybrids and if their comfort zone differs, fast growing broilers might need lower temperatures than used in this study, can also be of interest.

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Fakulteten för veterinärmedicin och husdjursvetenskap
Institutionen för husdjurens miljö och hälsa
Box 234
532 23 Skara
Tel 0511–67000
E-post: hmh@slu.se
Hemsida: www.slu.se/husdjurmiljohalsa

Swedish University of Agricultural Sciences
Faculty of Veterinary Medicine and Animal Science
Department of Animal Environment and Health
P.O.B. 234
SE-532 23 Skara, Sweden
Phone: +46 (0)511 67000
E-mail: hmh@slu.se
Homepage: www.slu.se/animalenvironmenthealth