Final report, project number H1343143

1. Project title, project number and report author

Project title: Sustainable production system for organic poultry meat – Effect of breeding material and production environment on productivity, animal welfare and environmental load.

Project number: H1343143

Report author: Ass. Professor Anna Wallenbeck, Department of Animal Breeding and Genetics, Swedish University of Agricultural Sciences

2. Background

Over the last 50 years, the Swedish broiler production has made a fivefold increase in the number of chickens slaughtered, and a six fold increase in tonnes meat produced per year (FAOSTAT, 2015). These numbers indicate an enormous development of the efficiency of the production in general and the broilers specifically. Over the last 10 years, increased consumption of chicken meat has led to a 25 % increase in the poultry meat production in Sweden. Even so, the self-sufficiency rate has decreased with about 10 % in the same period (Swedish Board of Agriculture, 2015). One contributing factor is the organic broiler production, which doesn't correspond with the increased demand for organic products.

Organic broiler production is characterized by diets based on locally produced organic feedstuffs, roughage allowance, a long rearing period, large space allowance, outdoor access for the birds and ban of prophylactic use of antibiotics and anthelmintic (EEC, 2007, IFOAM, 2016, KRAV, 2016). One major emphasis that differentiates organic from conventional broiler production is the focus on long rearing periods and thus low to moderate growth rates. In organic production, birds that are not from slow-growing stains should be reared until at least 81 days of age (slow-growing stains may be slaughtered at 70 days of age unless also the parent stock is kept organic ant there are no slaughter age limits), and thus not exceed a growth rate higher than 45 g/day (EC 2014).

Despite a high demand from consumers for organic broiler meat, organic broiler production in Sweden has remained at a low level (below 0.5% of total broiler production), mainly due to animal welfare issues (e.g. leg weakness) related to a lack of suitable broiler hybrids. However, organic broiler production is currently (2015-2016) increasing strongly (Swedish Board of Agriculture, 2016) and one reason for this is the recent introduction of slower-growing hybrids, Rowan Ranger and Hubbard Label Organic, on the Swedish market. Scientific reports on production performance, welfare and behaviour in these hybrids in Swedish commercial production environments are scarce, but the few studies available report e.g. altered behaviour compared with fast-growing hybrids (Karlsson, 2016, Wedin, 2016). The current rapid increase and development of organic and free-range broiler production in e.g. Sweden has increased the demand for relevant scientific knowledge on the production performance, welfare and behaviour and of different genotypes in such systems, in order to promote sustainable development of these production systems.

2.1 Fast and slower growing broiler hybrids

Modern breeding has over the last 50 years 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 drastic 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, 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). Thus these fast growing broiler hybrids are bred for efficient production in strictly controlled indoor environments with access to high quality diets, not production environments with the characteristics of organic production and it has been debated whether they should be used at all in production systems with longer rearing periods (Knowles et al., 2008, Eriksson et al., 2009).

2.2 Organic diets and broiler growth

The composition of organic broiler diets is dependent on availability and price of organic feedstuff, especially protein rich feed stuff. As synthetic amino acids are not allowed in organic production (EC, 2007), the amino acid profile in organic broiler diet is solely determined by the protein sources in the feedstuffs. Thus the protein profile is not as optimized in relation to the protein demands of the bird as conventional broiler diets are, and organic broiler production has thus higher on-farm emissions of nitrogen per kg live weight (Bokkers and de Boer, 2009).

One way to prevent the birds from growing too fast in organic production is to apply restricted feeding. However, studies have shown that it is difficult to control the growth rate of fast-growing hybrids to the level required by organic production regulations (Eriksson et al., 2009; EC, 2007). The nutrient requirements of fast-growing broilers are crucial and if the diet is deficient in essential amino acids, over-consumption of feed may occur in an attempt to resolve the deficiency. This may lead to an over-consumption of protein which is not efficiently digested by the bird and thus lead to more nitrogen leakage to the surrounding environment (Morse, 1995).

2.3 Welfare – health and behaviour

Knowledge about broiler behaviour and health and how they respond in different environments is necessary to obtain a good animal welfare. Regarding broilers, measurements of mortality, behaviour and physiology can be used to estimate welfare (Dawkins et al., 2004). According to the EU-funded project Welfare Quality® (FOOD-CT-2004-506508), four principles should be used to assess farm animal welfare; "Good feeding", "Good housing", "Good health" and "Appropriate behaviour" (Welfare Quality®, 2009). Some of the most important welfare issues in broilers are poor leg health along with low prevalence of natural behaviour (Weeks et al., 2000).

One important animal welfare aspect highlighted in the general organic principles and in specific organic regulations is respect for natural animal behaviour and thus promotion of the possibilities and abilities of animals to perform highly motivated species-specific behaviours (often referred to as behavioural needs) (EEC, 2007, IFOAM, 2016, KRAV, 2016).

2.4 Aim and objectives

The overall aim of the project has been to contribute relevant scientific knowledge enhancing a sustainable development of organic broiler production in Sweden. The specific objectives have been to:

- Map, quantify and compare growth, behaviour and health between one fast-growing broiler genotype (Ross 308 (R)) and one slower-growing broiler genotype (Rowan Ranger (RR)) when organic diets with different protein content during a 10 weeks rearing period in a controlled environment.
- Map and compare perching and resting behaviour as well as mortality and growth in one fast-growing broiler genotype (Ross 308 (R)) and two slower growing genotypes (Rowan Ranger (RR) and Hubbard (H)) reared under commercial EU-organic conditions until 12 weeks of age.

2.5 References

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3. Material and methods

The project was divided into two experiments. In ***experiment 1*** (controlled environment in small broiler groups on research farm) we assessed the effect of hybrid (fast or slower growing) and protein levels in organic diets on broiler growth, health, and behaviour. Experiment 1 was coordinated with the SLU EkoForsk project "Mussel meal in organic broiler diets", thus one additional feed treatment (mussel diet) was included as compared to the objectives and plans of the present project. This contributed with additional information and replicates in the welfare and behaviour assessments aimed for the present project. In ***experiment 2*** (commercial EU-organic environment) we assessed effect of hybrid (one fast and two slower growing) on perching and resting behaviour as well as on mortality and growth.

3.1 Experiment 1 (research flock)

The experiment was performed at the Swedish Livestock Research Centre, Swedish University of Agricultural Sciences (SLU), Lövsta-Uppsala (latitude 60° north) between May 21st and 9th of July 2015. The experiment and all procedures involved were approved by the National Ethics Committee for Animal Experiments in Uppsala (C9/15).

3.1.1 Animals and housing

The setup of the experiment was in accordance with the Swedish commercial organic broiler production (KRAV Regler kap. 5.5), except for access to outdoor runs, and included two chicken genotypes and three experimental diets. In total 645 day-old broiler chickens entered the study, of which 328 fast growing Ross 308 (R) hybrids and 317 slow growing Rowan Ranger (RR) hybrids. Both hybrids were supplied by the breeding company Aviagen and were reared for 10 weeks.

At the start of the study all chickens were randomly divided in to 30 pens with 19-22 chickens in each, forming six genotype*diet combinations and five replicates per combination, allocated in altered order in floor pens in a climate controlled building (Table 1). The pens were separated by wire mesh, had open tops and wood shaving litter. Each pen contained one hanging feed dispenser, three water nipples and three 50 cm long wooden perches with rounded corners (33 mm in diameter) at 15, 30 and 45 cm high, placed above each other at a 45° angle. Continuous artificial light was used on the first three days, followed by a gradual increase of the dark period to six hours by day 8. Windows were covered to 80% during the light period, but completely covered during the dark period. Artificial lighting was gradually turned on and off to mimic dawn and dusk, respectively.

3.1.2 Experiment feed (low and high protein diets)

All birds were fed the same starter diet ad libitum for the first two weeks. From week 3 they received an experimental diet (ad libitum) which consisted of either a low-protein diet (low amino acid content) or a more conventional diet formulated according to recommendations as a high-protein diet, for more detailed information on the diet compositions see Rezaei et al (2016). Each pen of birds was provided with 2 kg pelleted straw per week as a roughage substitute.

*Table 1. Broiler hybrid, average daily gain according to Aviagen, feed treatment and number of chickens and pens (replications) per hybrid*diet group at 2, 6 and 9 weeks of age*

	Average daily gain		**Number of chickens (number of pens)[2]**		
Hybrid	**(g)[1]**	**Treatment**	**2 weeks**	**6 weeks**	**9 weeks**
Ross 308	72.32	High	109 (5)	109 (5)	101 (5)
		Low	107 (5)	103 (5)	94 (5)
		Mussel	109 (5)	83 (4)	75 (4)
Rowan Ranger	44.22	High	105 (5)	105 (5)	102 (5)
		Low	104 (5)	102 (5)	99 (5)
		Mussel	102 (5)	79 (4)	76 (4)
Total number chickens (pens)			636 (30)	581 (28)	547 (28)

[1] approximate average daily gain when reared to 9 weeks in commercial production (Aviagen, 2014a, Aviagen, 2014b),
[2] 19- 22 chickens in each pen at the start of the experiment.

3.1.3 Data recording

Birds and feed were weighed at pen level every week for determination of growth rate, feed intake and feed efficiency. At 70 days of age all birds were individually weighed to determine within-pen variation in bird weight. At 71 days of age the birds were slaughtered by electric stunning followed by bleeding. Individual live body weight before slaughter and slaughter weight (carcass without intestines, heart, proventriculus, gizzard, liver, head, neck and feet) were recorded for 5 randomly selected birds per pen. In addition, weight from 1 breast and 1 leg was

recorded for two birds per pen. Breast meat included only breast meat, without skin, while leg meat included meat and bone of the upper leg, without skin.

The behavioural observations were designed to study a combination of broiler time budgets, social behaviours and comfort behaviours (for details see Wallenbeck et al. 2017)). The behaviour of the broilers was recorded at 2, 6 and 9 weeks of age. All observations were performed during daytime, between 10 am and 3 pm.

Welfare Quality Assessment was done according to the Welfare Quality ® Protocol for poultry (Algers, 2009) at 2, 6 and 9 weeks of age (for details see Wilhemsson, 2016). The WQ protocol is developed for on-farm assessments, hence in this study relevant parameters was used and to some extent adjusted for recordings on individual animals.

Mortality and culling were recorded continuously and causes of death and culling were also recorded. At 1 week of age, the proportion of birds with sticky droppings (defined as faeces attached around or close to the cloaca of the bird) was recorded in each pen.

3.1.4 Statistical Analysis

Statistical analyses were performed using SAS software version 9.3. Descriptive statistics were calculated with proc FREQ and proc MEANS and differences between hybrids and diets were analysed with fixed and mixed general linear models in procedure GLM and proc GLM and proc MIXED. For the detailed models and assumptions see scientific publications and presentations from the project listed under the heading “Publications” below.

3.2 Experiment 2 (commercial environment)

This study assessed welfare and production in broiler chickens of different hybrids housed under commercial EU-organic conditions, however due to disease protection reasons, as one of the hybrids was imported from Denmark, the birds could not be given access to an outdoor environment. The study was conducted at a farm in South West Sweden between November of 2015 and January of 2016. The study was approved by the Gothenburg local Ethical Committee of the Swedish National Board for Laboratory Animals (reference no. 112-2015).

3.2.1 Animals and housing

The boiler chickens used in the experiment were from the hybrids; Ross 308 (fast growing, Avigen, called Ross hereafter), Rowan Ranger (slow grower, Aviagen) and Hubbard CYJA57/Label Organic (slow grower, Color Yield x JA57, called Hubbard hereafter); 100 birds of each hybrid. Chicks of the three hybrids were kept in separate round brooders cardboard until day 4 when they were mixed in one single pen (20 m x 7.5 m) littered with wood shavings, i.e. the stocking density was 2 birds per m2. Temperature and lighting was according to the manuals of the hybrids. Bird condition as well as temperature, food and water were checked once daily. The birds had access to five wooden perching contraptions placed in the middle of the pen with perches at 20, 40 and 70 cm height with 15 cm of total perch space per bird.

The house had an artificial light period each day between 05:00-23:00 h and daylight through large windows facing north, east and south.

3.2.2 Experiment feed

During the entire study the birds had ad libitum access to water and a commercially available organic feed (24.0 % CP and 12.5 MJ from 0-10 days of age and then successively the grower feed was introduced, containing 14.5 % CP and 11.7 % MJ) until slaughter. Roughage was provided in the form of Lucerne straw cuttings (4-5 cm long) starting at 2 kg per day and increasing gradually to the maximum allowance of 6 kg per day in total to the 300 birds at time of slaughter.

3.2.3 Data recording

All birds were weighed individually day 11, 45, 61 and 80 and slaughtered at day 84 at and carcass weight was recorded individually at slaughter. Mortality was recorded continuously and birds that were severely sick or had problems to find food or water due to inability to walk were euthanized by a hard blow to the head to stun the bird followed by neck dislocation.

Continuous observation of focal birds during 10 minutes was carried out four times during the rearing period. Scan sampling on day time was performed in pre-determined areas 2*2 m, containing perches, drinker and feeder. All birds performing the behaviours listed in table 2, were registered. Night scans were performed 30 minutes after the lights were turned off, on three occasions during the rearing period on the whole group. As Rowan Ranger and Hubbard birds could not be differentiated in the dark all birds perching were registered as Ross or slow growing.

Table 2. Ethogram perching and disturbance behaviours

Behaviour	Definition
Perch	Chicken sits still on perch
Sleep	Chicken holds head in a low posture with eyes closed, under the wing, or rests it on the bedding
Lie down	The breast of the chicken touches the bedding
Preform disturbance	Other chicken abandons sleep or lie down position due to physical contact initiated by focal chicken
Receive disturbance	Focal chicken abandons sleep or lie down position due to physical contact initiated by another bird

3.2.4 Statistical Analysis

Statistical analyses were performed using SAS software version 9.3. Descriptive statistics were calculated with proc FREQ and proc MEANS, chi square test were performed using proc FREQ, correlations were estimated using proc CORR and differences between hybrids were analysed with general linear models in proc GLM. For the detailed models and assumptions see scientific publications and presentations from the project listed under the heading "Publications" below.

4. Results

4.1 Mortality, growth and carcass performance

4.1.1 Experiment 1 (research farm)

The proportion of birds culled because of leg weakness was higher among Ross than among Rowan Ranger birds (10.0 ± 2.0 and 3.3 ± 2.0% respectively, P = 0.031) and tended to be higher among birds fed the low-protein diet than among birds fed the high-protein diet (9.2 ± 2.0 and 4.1 ± 2.0 % respectively, P = 0.092).

The Ross birds had a higher growth rate than the Rowan Ranger birds, resulting in higher mean live weight and carcass weight at slaughter (Table 3). Analysis of interactions the interaction between hybrid and diet for growth rate (P=0.002) showed that Ross birds grew slower when fed the high-protein feed than when fed the low-protein feed (55.3 ± 0.5 versus 57.8 ± 1.4 g/day, P = 0.050). However, Rowan Ranger birds grew faster when fed the high-protein feed than when fed the low-protein feed (39.4 ± 0.7 and 37.2 ± 0.4 g/day, P = 0.038). There were no differences between hybrids or diets and no interactions between hybrid and diet regarding within-pen variation in live weight at slaughter.

*Table 3.Feed intake and feed conversion over the 10 week rearing period and carcass composition in the High (H) and Low (L) protein diets and in the fast-growing (R) hybrid and slow-growing (RR) hybrid. LSM ± SE, N = 20 pens, 5 pens per genotype*diet treatment. The interaction between Hybrid and Diet was not significant (P>0.05) for any of the variables presented in the table.*

	Dietary protein level			Hybrid		
Variable	H	L	P	R	RR	P
Daily feed intake (g/day)	127.8 ± 0.60	126.5 ± 6.80	0.769	143.7 ± 3.73	110.6 ± 1.78	0.001
Feed conversion ratio (kg feed/kg weight gain)	2.8 ± 0.03	2.7 ± 0.10	0.489	2.6 ± 0.05	2.9 ± 0.04	0.001
Weight 1 day before slaughter (g/bird)	3426 ± 50.8	3377 ± 50.8	0.200	3986 ± 50.8	2817 ± 50.8	0.001
Standard deviation in weight in the pen 1 day before slaughter (g/pen)	436 ± 25.0	467 ± 25.0	0.402	414 ± 75.6	490 ± 75.6	0.611
Live weight at slaughter (g/bird)	3467 ± 120.2	3239 ± 120.2	0.414	4050 ± 120.2	2656 ± 120.2	0.001
Carcass weight (g/bird)	2505 ± 55.7	2439 ± 55.7	0.359	2975 ± 55.7	1969 ± 55.7	0.001
Dressing percentage (carcass as % of live weight)	71.9 ± 5.65	79.9 ± 5.65	0.332	73.3 ± 5.65	78.5 ± 5.65	0.529
Breast meat percentage (breast as % of carcass)	25.5 ± 0.79	25.5 ± 0.79	0.965	26.8 ± 0.79	24.3 ± 0.79	0.039
Leg meat percentage (leg meat as % of carcass)	30.9 ± 0.83	29.7 ± 0.83	0.307	30.5 ± 0.83	30.1 ± 0.83	0.759

4.1.2 Experiment 2 (commercial environment)

Mortality from day 0 to 84 (including culling) was much higher for Ross than for Rowan Ranger and Hubbard, as was weight at slaughter (Table 4).

4.2 Behaviour

4.2.1 Experiment 1 (research farm)

Time budgets for broiler behaviour

Broilers of the Rowan Ranger hybrid were significantly more active than the Ross broilers, as indicated by a larger proportion of time spent standing (36±2.6% compared with 27±2.6%, p=0.021, N=60) and a lower proportion of time spent sitting (57±2.4% compared with 65±2.4%, p=0.028, N=60). Furthermore, Rowan Ranger broilers spent more time perching during daytime (6±0.8% compared with 2±0.8%, p=0.002, N=60) and less time eating and drinking (9±1.3% compared with 16±1.3%, p=0.002, N=60) than Ross broilers. There were no differences between the broilers of the different hybrids regarding proportion of time spent sleeping or foraging. Furthermore, type of diet or interactions between hybrid and diet did not significantly affect broiler behaviour.

Regarding changes in behaviour with age, for broilers of both hybrids the time spent standing decreased during the latter part of the rearing period (37a±3.2%, 36a±3.2% and 21b±3.2% in week 2, 6 and 9, respectively; p=0.002, different superscripts indicate pairwise differences at p<0.05, N=60) and time spent sitting increased (52a±2.9%, 57a±2.9% and 74b±2.9% in week 2, 6 and 9 respectively; p=0.001, N=60). Time spent perching peaked at week 6 (4ab±0.9%, 6a±0.9% and 2b±0.9% in week 2, 6 and 9, respectively; p=0.026, N=60). Foraging decreased with age (5a±0.6%, 2b±0.6% and 1b±0.6% in week 2, 6 and 9, respectively; p=0.001, N=60) (Figure 2). There were no significant changes with age in proportion of time spent sleeping (numerically decreasing from 9±1.3 to 6±1.3 % of time from week 2 to week 9 of rearing) or in time spent eating or drinking.

Table 4. Mortality (including culling), sex ratio and slaughter weight of the three broiler hybrids measured at 82 days of age. Different superscript letters within the same row indicate pair-wise differences with P<0.001. Weight is given in grams and mortality is given in percent within hybrid.

Parameter	Ross	Rowan Ranger	Hubbard	P-value	Test statistics
Mortality (%)	20^a	2^b	2^b	0.001	χ^2= 29.4
Sex ratio (M/F)	0.86	0.78	1.09	0.503	χ^2= 1.4
Slaughter weight females (grams, LSM±SE)	5487 ± 67^a	3377 ± 59^b	3319 ± 64^b	0.001	F= 372.2
Slaughter weight males (grams, LSM±SE)	6697 ± 72^a	4324 ± 67^b	4248 ± 62^b	0.001	F= 372.2
Slaughter weight total (grams, LSM±SE)	6092 ± 49^a	3850 ± 45^b	3783 ± 44^b	0.001	F= 758.2

Social interactions and comfort behaviours

There was great variation between behaviours in frequency of performance. Some social interactions were observed at very low frequencies or not at all (i.e. running, group running, play fighting, aggressive pecking, dustbathing, flying, food running, severe feather pecking). There were no significant (p<0.05) effects of hybrid, diet, age, interactions between hybrid and diet or interactions between hybrid and age on any of the behaviours. However, there was a tendency (p=0.055) for broilers fed the High protein diet to stretch their legs and wings more often than broilers fed the Low protein diet (30±5.2% and 17±4.2% of the focal animals in the High protein and Low protein treatment, respectively, performed the behaviour).

4.2.2 Experiment 2 (commercial environment)

Night-time perching

R birds perched significantly less than Rowan Ranger and Hubbard during night-time (Fig. 1, Table 7). Ross only perched on the lowest perches, whereas Rowan Ranger and Hubbard perched on all heights (Table 7). Ross birds showed a decline in perching frequency over time (day 63 versus 70 $\chi2$=4.4, P=0.036 and day 63 versus 77 $\chi2$=4.0, P=0.045) while Rowan Ranger and Hubbard birds showed no significant difference between the first and last observation ($\chi2$=2.4, P=0.12) despite a decline at day 70 when compared to day 63 ($\chi2$=13.8, P<0.001) (Figure 1).

Day-time perching

A lower number of Ross birds perched during day-time than Rowan Ranger at day 76 (P=0.012) and Hubbard at day 80 (P= 0.020) (Fig. 3), while they perched less than both other hybrids in total (R versus Rowan Ranger P= 0.005; Ross versus Hubbard P= 0.011) (Figure 3; Table 8).

Disturbing and activity behaviour

Gender significantly affected occurrence of performing disturbing behaviour towards resting birds (F=5.6, P=0.020,) but not receiving (F=0.0, P=0.983,) disturbance during resting and it was the male birds who performed disturbance behaviour more frequently (21.9% of all observations of roosters versus 5.9 % of all observations of

hens). There was no significant effect of genotype on performing (F=0.7, P=0.505) or receiving (F=0.3, P=0.713) disturbance and there were no significant pairwise differences.

A significant residual correlation was found between sleeping and lying (r=0.29, P=0.002) and a tendency for a correlation was found between sleeping and performing disturbance (r=0.16, P=0.087) as well as between lying and receiving disturbance (r=0.17, P=0.070).

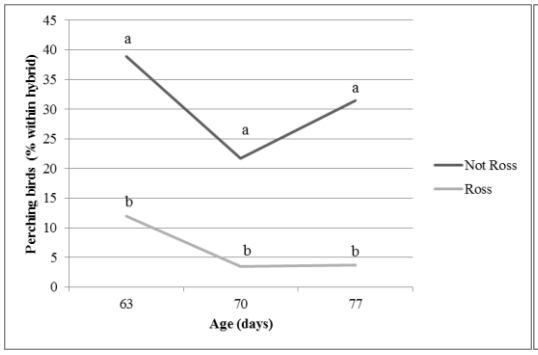

Figure 1. Perching behaviour displayed at night-time during the late part of rearing (N=30 observations). Not Ross=Rowan Ranger and Hubbard birds. Different superscript letters within the same day indicate pair-wise differences (χ2) with P<0.001.

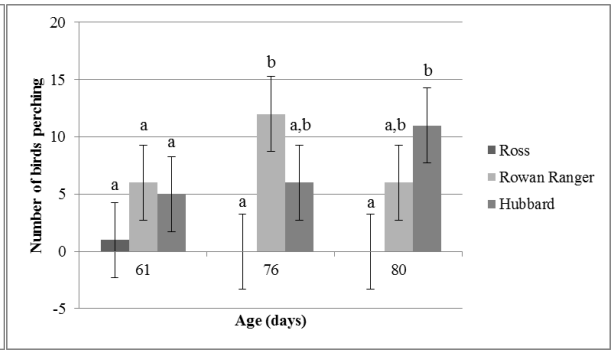

Figure 2. Perching behaviour displayed at day-time during the late part of rearing (N=90 observations). Different superscript letters within the same day indicate pair-wise differences with p<0.05.

Table 7. Mean perching frequency during night-time per observation day (day 70 or 77). Data is presented as percent of total birds within hybrid (LSM±SE). Slow growing=Rowan Ranger and Hubbard birds. N=20 observations.

Perch height	Ross	Not Ross	P-value	F-value
Low	3.6 ± 0.64	15.2 ± 0.64	<0.001	167.3
Medium	0.0 ± 0.83	3.0 ± 0.83	0.061	6.7
High	0.0 ± 1.29	8.4 ± 1.29	0.010	21.2
Total	3.6 ± 2.33	26.6 ± 2.33	0.002	49.0

Table 8. Perching and sleeping frequency per day during day-time group scan observation at day 61, 76 and 80. Data is presented as LSM±SE and number of birds per observation. Different superscript letters within the same row indicate pair-wise differences with p<0.05. N=90 observations.

Behaviour	Ross	Rowan Ranger	Hubbard	P-value	F-value
Sleeping	0.87 ± 0.026	1.17 ± 0.026	0.80 ± 0.26	0.566	0.6
Perching	0.03^{a} ± 0.019	0.80^{b} ± 0.019	0.73^{b} ± 0.019	0.009	5.0

4.3 Welfare

4.3.1 Experiment 1 (research farm)

A larger proportion of Ross birds than Rowan Ranger birds had sticky droppings at 1 week of age (18.6 ± 1.6 and 3.8 ± 1.6%, respectively, P = 0.001) and the proportion were lower among birds fed the low-protein diet than among birds fed the high-protein diet (8.7 ± 1.6 and 13.8 ± 1.6% respectively, P = 0.042).

The proportion of birds scored to show poor welfare indicators (panting, with abnormal gait, having dirty plumage, having foot pad and hook dermatitis) were higher among Rowan Ranger birds than among Ross birds (Figure 3). The proportion of birds scored as panting, with abnormal gait, having dirty plumage, having foot pad and hook dermatitis increased with age in birds of both hybrids (Figure 4).

5 Discussion

Here follows a brief discussion and interpretation of results. For thorough scientific discussions, see scientific publications and presentations from the project listed under the heading “Publications” below.

5.1 Mortality, growth and carcass performance

5.1.1 Experiment 1 (research farm)

The fast-growing Ross birds grew faster when fed the low protein diet and the slower-growing Rowan Ranger birds grew faster when fed the high protein level diet, indicating differences in the response to dietary protein levels between these two hybrids. Although the Ross birds were more efficient from a feed conversion point of

view, and therefore in theory more resource-efficient, the high mortality and culling rate observed in Ross birds should also be considered in relation to resource efficiency. Furthermore, high mortality because of growth related leg problems during the late rearing period in the Ross birds raise strong ethical concerns about using fast-growing birds in production systems with long rearing periods.

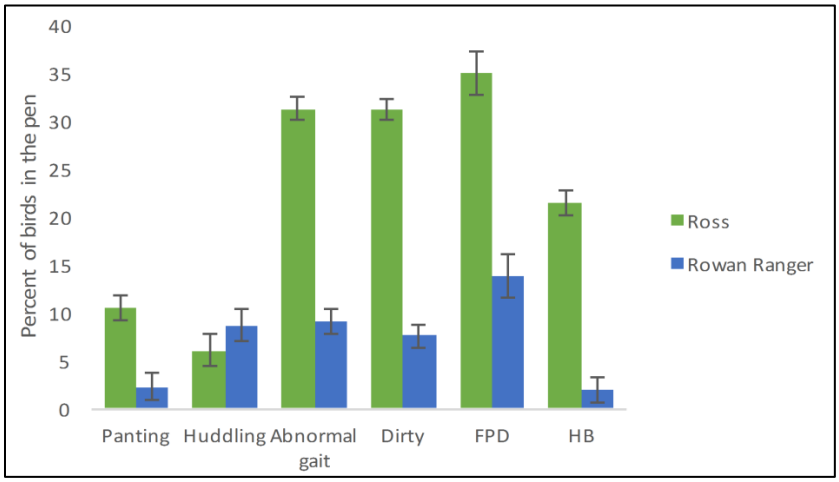

Figure 3. Differences in proportion of birds scored as panting, huddling, with abnormal gait, having dirty plumage, having foot pad and hook dermatitis between hybrids. Significant differences (P<0.0001) for all except huddling. Averages per observation session over observations at week 2, 6 and 9.

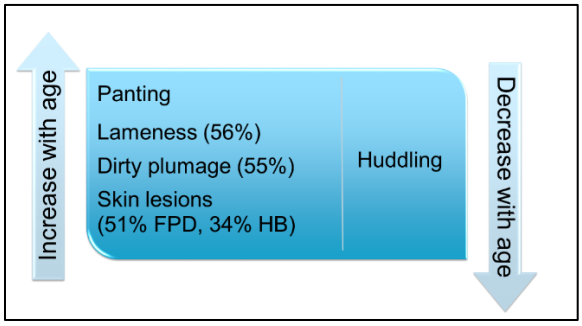

Figure 4. Changes with age, increase and decrease in occurrence of indicators of poor welfare. Proportions of birds with confirmed disorder (both hybrids at 9 weeks).

5.1.2 Experiment 2 (commercial environment)

As expected the fast growing Ross hybrid grew faster and had higher slaughter weight than Rowan Ranger and Hubbard birds. It is noteworthy that Rowan Ranger and Hubbard did not differ in average slaughter weights and that there was a large variation in slaughter weight within hybrid. A high proportion of the Ross birds died or was culled due to health problems during this study (20% compared to 2 % in Rowan Ranger and Hubbard birds). Even though mortality is not the finest of instruments to measure welfare this is a clear indication that health, and thus welfare, is low (EFSA, 2012). Therefore the high mortality in Ross birds indicates reduced welfare. Within EU-organic production, the choice of hybrid should strive to prevent animal suffering (EC, 2008). Based on the results of the present study showing that the broilers' physique inhibits them to perform the highly motivated behaviour of perching and cause high levels of mortality and culling, it may be concluded that Ross birds experience reduced welfare when reared until 12 weeks of age.

5.2 Behaviour

5.2.1 Experiment 1 (research farm)

The fast-growing Ross broilers are less active and sit, eat and drink more frequently than slower-growing Rowan Ranger broilers, which in turn stand and perch more frequently. However, broilers of both hybrids showed decreasing activity and foraging behaviour with increasing age, while time spent eating and sleeping was approximately similar over the entire rearing period. The results indicate that high live body weights and the corresponding physical abilities are major factors affecting broiler behaviour. Nevertheless, the behavioural pattern among broilers of the slower-growing hybrid Rowan Ranger birds was more in accordance with the

important species specific behaviours observed in i.e. the red jungle fowl, compared to the behavioural pattern among broilers of the fast-growing hybrid.

5.2.2 Experiment 2 (commercial environment)

There are differences in perching frequency between broiler chickens of strains of different growth rate, as the fast growing Ross birds perched significantly less than the slow growing Rowan Ranger and Hubbard birds. Birds sleeping on the floor were exposed to high frequency of disturbed sleeping bouts, and hence sleeping and resting on perches or other elevated structures would be desirable in broiler rearing. In the present study it was found that males disturbed other resting birds more frequently than females. The results combined imply that the Ross birds experience reduced welfare compared to the slow growing hybrid birds. It is therefore recommended that Ross birds are not used in EU-organic production with 12 weeks rearing periods. Furthermore it is recommended that perches are provided within EU-organic production to allow broilers to express the highly motivated behaviour of perching.

4.3 Animal welfare

The results from the Welfare Quality assessment show that Ross chickens have poor welfare when reared to 10 weeks. Health problems also increases for Rowan Ranger with age, but to a lower extent. This indicated that other genotypes (e.g. more slow growing and/or robust than Rowan Ranger), and/or altered management practiced during the latter part of rearing might be needed suitable for rearing periods >9 weeks.

4.4 References

6 Publications

Project publications and presentations, including links to relevant documents are available at the project homepage: http://www.slu.se/fakulteter/vh/forskning/forskningsprojekt/fjaderfa/produktionssystem-for-ekologisk-kycklingkott

6.1 Scientific publications - published

Wallenbeck, A., Wilhelmsson, S., Jönsson, L., Gunnarsson, S. and Yngvesson, J. 2017. Behaviour in one fast-growing and one slower-growing broiler (Gallus gallus domesticus) hybrid fed a high or low protein diet during a 10-week rearing period. Acta Agriculturae Scandinavica, Section A Animal Science. DOI: 10.1080/09064702.2017.1303081

Rezaei, M., Yngvesson, J., Gunnarsson, S., Jönsson and Wallenbeck, A. 2017. Feed efficiency, growth performance and carcass characteristics of a fast and a slower growing broiler hybrid fed low- or high-protein organic diets. Organic Agriculture. DOI: 10.1007/s13165-017-0178-6.

Wilhelmsson, S. 2016. Comparison of behaviour and health of two broiler hybrids with different growth rates. MSc thesis in Animal Science. Department of Animal Environment and Health, Swedish University of Agricultural Sciences.

Wedin, M. 2016. Perching Behaviour and Disturbance during Sleep in Three Hybrids of Broiler Chicken (Gallus gallus domesticus). 2016. BSc thesis in Biology. Department of Animal Environment and Health, Swedish University of Agricultural Sciences.

6.2 Scientific publications – in well-developed manuscript form

Yngvesson, J., Wedin, M., Gunnarsson, S., Jönsson, L., Blokhuis, H. and Wallenbeck. A. 2017. Perching and disturbance behaviour during resting in fast- and slow growing broiler (Gallus gallus domesticus) hybrids. To be submitted to Applied Animal Behaviour Science in July 2017.

Wilhelmsson, S., Yngvesson, J., Jönsson, L., Gunnarsson, S. and Wallenbeck, A. 2017. Welfare quality ® assessment of a fast and a slower growing broiler hybrid reared until 10 weeks. To be submitted to Livestock Science in July 2017.

Jönsson, L., Gunnarsson, S., Yngvesson, J., Rezaei, M and Wallenbeck, A. 2016. Effects of hybrid and dietary mussel meal on broiler production during 10 weeks of rearing. To be submitted to Acta Agriculturae Scandinavica, Section A Animal in August 2017.

6.3 Scientific presentations

Gunnarsson, S., Jönsson, L., Rezaei, M., Wilhelmsson, S., Yngvesson, J. and Wallenbeck, A. 2017. Performance and Welfare in one fast-growing and one slower-growing broiler (Gallus gallus domesticus) hybrid fed a high or low protein organic diets during a 10-week rearing period. 11th International Veterinary Behaviour Meeting, Bratislava, 14-17 of September 2017

Wilhelmsson, S., Yngvesson, J., Jönsson, L., Gunnarsson, S. and Wallenbeck, A. 2017. Welfare quality ® assessment of a fast and a slower growing broiler hybrid reared until 10 weeks. Poster presented at the faculty day of the Faculty of Veterinary Medicine and Animal Science, Uppsala June 16th 2017.

Jönsson, L., Gunnarsson, S., Yngvesson, J., Rezaei, M and Wallenbeck, A. 2016. Effects of hybrid and dietary mussel meal on broiler production during 10 weeks of rearing. Proceedings of the 67th congress of the EAAP, Belfast, United Kingdom. p. 564.

Yngvesson, Y., Gunnarsson, S., Jönsson, L., Wallenbeck, A. 2016. Behaviour of broilers in semi-commercial organic rearing – behaviour and mortality of hybrids with rapid or slow growth rate., that you have Congress of the International Society for Applied Ethology (ISAE), Edinburgh, United Kingdom. Abstract number 23777. Poster presentation

Wilhelmsson, S., Bruce, P., Wallenbeck, A., Gunnarsson, S., Jönsson, L., Yngvesson, J. 2016. Behaviour and health of in two broiler hybrids with different growth rates. The 26th Nordic Symposium of the ISAE, Vejle, Denmark.

Rezaei, M and Wallenbeck, A. 2015. Feed conversion, growth performance and health in slow and fast growing broiler hybrids. Poster presented at the faculty day of the Faculty of Veterinary Medicine and Animal Science, Uppsala October 14th 2015.

7 Conclusions (related to usefulness and advice for the sector)

- The fast-growing Ross hybrid and the slower-growing Rowan Ranger differed in the response to dietary protein levels, emphasising the need for hybrid adjusted diets.
- As expected the fast growing Ross hybrid grow faster and have higher slaughter weights than both Rowan Ranger and Hubbard. There are no large differences in average growth rates or slaughter weight between the slower growing hybrids Rowan Ranger and Hubbard but there is a large variation in slaughter weight within both the Rowan Ranger and the Hubbard hybrids that may cause problems for farmers when matching slaughter weights with best paired slaughter weight interval.
- An unacceptably high proportion of the Ross birds die or needs to be culled due to leg and general health problems (up to 10 - 20 % of the birds depending on rearing length and production environment). This is a major animal welfare problem that also leads to severe production and profitability losses in commercial organic broiler production.
- The behavioural pattern among broilers of the slower-growing hybrid Rowan Ranger is more in accordance with the pattern of important species specific behaviours observed in i.e. the red jungle fowl compared to the fast-growing hybrid Ross and thus the natural behaviours that is referred to in organic regulations.
- The fast growing Ross birds perch less than the slow growing Rowan Ranger and Hubbard birds, mainly because of their physical inability rather than motivation to perch.
- Welfare Quality assessment show that Ross broilers have poor welfare when reared to 10 weeks of age. Health problems also increase for Rowan Ranger with age, but to a lower extent.
- The overall conclusion is that the fast growing broiler hybrid Ross are bred and suited for efficient production in controlled production environment with short rearing periods (slaughter at ≤5 weeks of age) and should not be used in organic production with longer rearing periods.

8 Result communication targeting the Swedish organic broiler sector

Project publications and presentations, including links to relevant documents are available at the project homepage: http://www.slu.se/fakulteter/vh/forskning/forskningsprojekt/fjaderfa/produktionssystem-for-ekologisk-kycklingkott

8.1 Popular scientific presentations

Yngvesson, J., Wallenbeck, A., Gunnarsson, S., Jönsson, L., Bruce, P. Wilhelmsson, S., Holstensson, K. and Wedin, M. 2016. Hybrider för ekologisk kycklingproduktion. Jordbruksverkets seminarium om forskning och utveckling inom ekologisk produktion, Skövde 20-21 September 2016.

Jönsson, L. 2016. Olika hybrider för ekologisk kycklingproduktion. SVA:s projektråd-fjäderfä, Swedish National Veterinary Institute. Uppsala 4-5 Oktober 2016.

Wallenbeck, A. 2014. Production systems for organic broiler production. SVA:s projektråd-fjäderfä, Swedish National Veterinary Institute. Uppsala 17-18 September 2014.

8.2 Popular scientific summaries and project mentioned in newsmedia

- Snabbväxande kycklingar är inte lämpliga i produktion med långa uppfödningstider – SLU Nyhet 2017-04-04 (http://www.slu.se/ew-nyheter/2017/4/beteendeskillnader-mellan-snabb--och-langsamtvaxande-kycklingraser/?si=386DC2357486017D91F942DAC4C9EA35&rid=1825493581&sn=sluEPi6-prodSearchIndex)
- Hur fungerar snabbväxande kycklingar i ekologisk produktion? SLU-nyhet 2017-03-14 (http://www.slu.se/ew-nyheter/2017/3/hur-fungerar-snabbvaxande-kycklingar-i-ekologisk-produktion/?si=386DC2357486017D91F942DAC4C9EA35&rid=1825493581&sn=sluEPi6-prodSearchIndex)
- Beteendeskillnader mellan två typer av slaktkyckling. SLU Forskningsnytt produktionsdjur, SLUs Kunskapsbank 2017-04-03 (http://www.anpdm.com/newsletter/4259686/41435B45714546584571)
- Kan inte möta efterfrågan på ekokyckling. ATL 2017-09-21 (http://www.atl.nu/lantbruk/kan-inte-mota-efterfragan-pa-ekokyckling/)
- Avel i kycklingindustrins tjänst. Tidningen Djurskyddet 2016-12-07 (http://tidningen.djurskyddet.se/2016/12/AVEL-I-KYCKLINGINDUSTRINS-TJANST/)
- Interview from ongoing experiment in the poultry stable at Lövsta in SR Radio Uppland 2015-06-15