Health and welfare observations in new broiler hybrids in Sweden

Hälsa och välfärd hos nya slaktkycklingshybrider I Sverige

Abdul kader Alhamed

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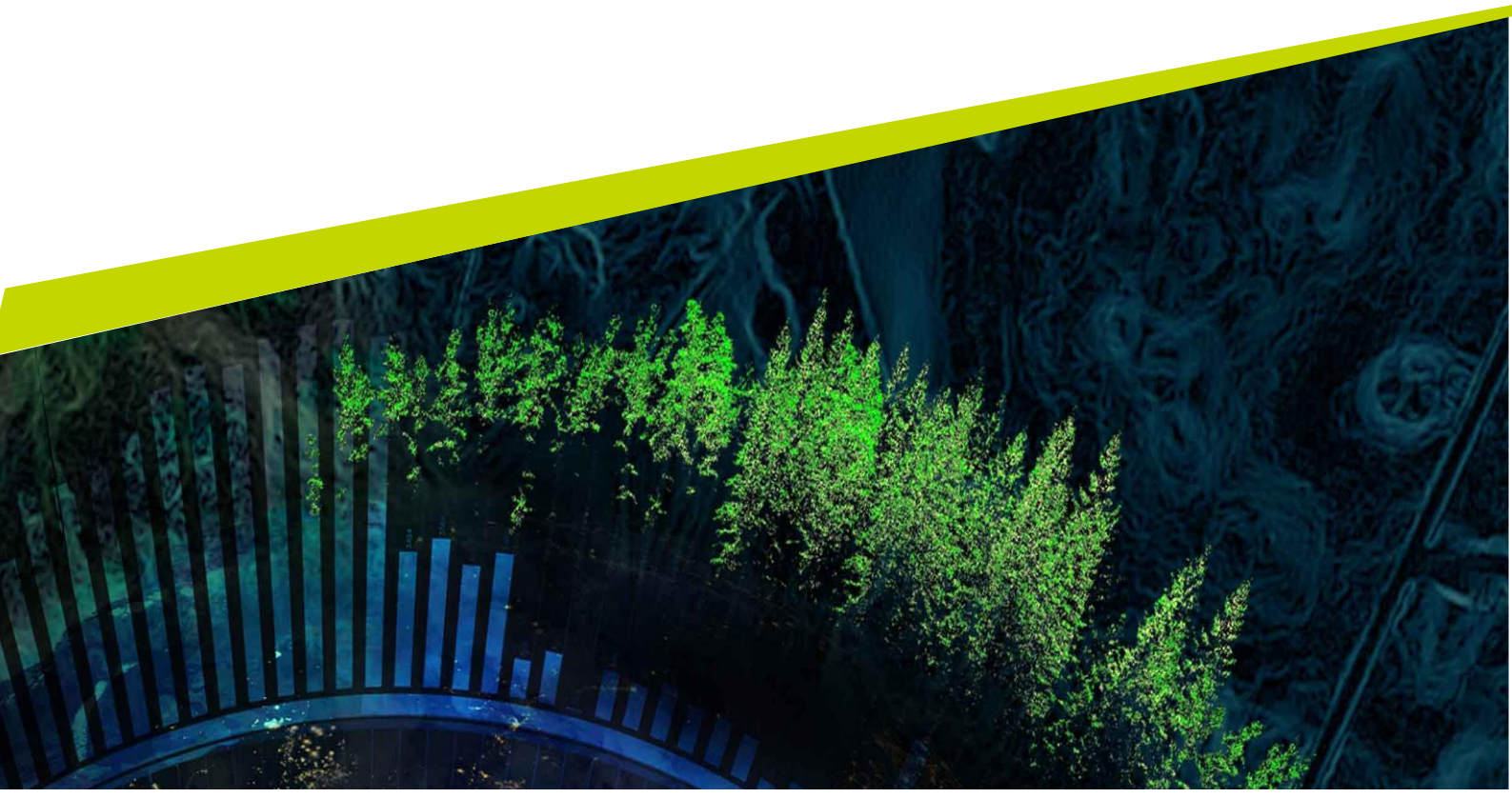

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Abstract:

The stronger demand from consumers and welfare society to introduce new breeds that fit for higher welfare and better sustainability has been a strong factor to start introducing new breeds to the Swedish market and to meet these strong demands. Two breeds has been chosen as interesting breeds to be studied in the Swedish market. Several parameters like weight gain, health and welfare indicators between two slow growing (SG) organic broiler hybrids, Rowan Ranger (RR) and Hubbard (H) were studied compared using two different housing systems, these two hybrids were chosen to be studied because they were the latest genotypes in the Swedish market and many organic farmers use them in their poultry production. Evaluation of performance, welfare and sustainability of these new genotypes is the key factor for the future of sustainable poultry production.

Two groups with 200 birds each were reared in a research centre facility until the age of ten weeks. Total body weight, carcass parts, plumage cleanliness, footpad dermatitis, hock burns, skeletal problems and gait score were recorded weekly with reporting the mortality and culled birds with the reason of culling.

Welfare Quality® protocol had been used to record welfare parameters on birds. There were some significant differences in some Welfare Quality® parameters between both hybrids. There was a significant difference in live weight, where RR had higher live weight and breast meat yield than H, nevertheless, there were no significant differences in the slaughter weight between both hybrids apart from that males had higher mean body weight in both hybrids and production systems than females.

Additionally, Welfare Quality indicators have been evaluated for both hybrids and production systems, RR showed to have more incidents of dirtiness in plumage and higher footpad dermatitis score comparing to H. Other welfare indicators did not significantly differ between hybrids or production systems.

Sammanfattning:

Den högre efterfrågan från konsumenter och djuvälfärd organisationer att intruducera hybrider som uppnå högre välfärd och bättre hållbarhet har varit en stark påverkande faktor till att göra flera vetenskapliga studier och undersökningar om nya kycklinghybrider som är långsamväxande och möter dessa krav.

Två raser som nyligen funnists i den Svenska marknaden och används av vissa kycklings uppfödare har valts att studeras i den här studien. Flera parametrar såsom, avkastning, hälsa och vissa välfärdparametrar mellan två långsamväxande ekologiska kycklighybrider, nämligen Rowan Ranger och Hubbard, har studerats. Studiens syfte var att jamföra mellan två olika inhyssningssystem med fokus på avkastning, välfärd och hållbarhet.

Två grupper med 200 fåglar vardera föds upp och i en förskningcenteranläggning fram till tio veckors ålder. Total kroppsvikt, stycknings delar, fjäderdräkten, dermatit i trampdynan, brännskador i hasen och skelettskador bedömdes varje vecka samt dödlighet, avlivade fåglar och slaktade registerardes veckovis.

En Welfare Quality® protokoll användes när välfärdparametrar registerades. Det fanns segnifikanta skillnader i Welfare Quality® parametrar mellan båda hybdrider. Avkastningen skilled sig mellan olika hybrider och kön, där RR hade högre levande vikt och bröstköttutbyte än H, det fans dock inga signifikanta skillnader i slaktviktavkatsning mellan båda hybdriderna. Hanar hade högre medelkroppsvik. Det fanns inga andra signifikanta olikheter i andra välfärdsparametrar mellan hybriderna och inhyssningssystem.

Keywords: Slow growing, organic, genotypes, welfare quality, Innovation.

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Abbreviations

FG	Fast growing
FPD	Footpad dermatitis
H	Hubbard
HB	Hock burns
MG	Medium growing
PC	Plumage cleanliness
RR	Rowan Ranger
SG	Slow growing
SLU	Swedish Agricultural University
WQ	Welfare quality

1. Background:

Rearing conventional broiler has been focusing on many aspects which affect profit at first hand, such as rapid growth, high feed efficiency and meat yield. Nowadays, chicken meat consumers start demanding meat produced in an animal-friendly environment, where the birds have a higher ability to express their natural behaviour, live in lower stocking densities and have better access to important functions such as outdoor range. Additionally, many consumers link organic labelled chicken meat with good welfare and higher health standards (Röcklinsberg and Lund, 2011.; Vaarst and Alrøe, 2012).

Broiler chickens have several behavioural needs such as having enough space for running, flapping and dustbathing in an adequate area, pecking, resting and sleeping on higher areas than the ground such as tree branches (Jensen, 2006, 2002; Mench, 1992; Weeks et al., 2000).

Organic poultry production became more common these days, and this type of production in Sweden is regulated according to European Council Regulation (EC) No. 834/2007 and many off organic production facilities can be certified according to the Swedish organic certification organization KRAV, which has special requirements additionally to what stated in European council regulation (European Council 2019; KRAV 2019). There are several characteristics to be fulfilled to consider a production system as organic poultry production, such as using organic certified feedstuff for feeding of animals, roughage allowance, long rearing periods, non-usage of antibiotics and anthelmintic and outdoor range access (European Council 2019; Krav 2019).

Animal welfare is a complex concept that is usually defined from several aspects and can interpret differently in different groups of people, several examples of welfare-related definition are good health and production, feelings and the ability to live according to the animal's nature and perform all their natural behaviours (Hewson, 2003). Many of these aspects alone can be insufficient and it is better to have a combination of all aspects to have a better welfare assessment. A definition of animal welfare can be as the physical and the emotional state of the species and that the animals should be able to express species-specific natural behaviour (Lund, 2006). Nowadays scientists consider good animal welfare as the presence of the positive state and absence of the negative state in an animal (Ohl and van der Staay, 2012). Another concept that has been established by Farm Animal Welfare Council (FAWC) is widely adopted by animal welfare scientists currently, this aspect is the five freedoms of animal welfare which are also known as Barmbell´s freedoms which includes 5 points: 1. Freedom from hunger or thirst; 2. Freedom from discomfort; 3. Freedom from pain, injury, or disease; 4. Freedom to express normal behaviour; and 5. Freedom from fear or distress (FAWC 2009).

Until recently broiler from fast-growing (FG) genotypes has been used in both organic and conventional poultry production in Sweden. Nevertheless, using FG genotypes in organic production which lasts for longer rearing periods (≥ 81 days compared to around 35-40 days for conventional broiler) could lead to increased mortality and culling percentages and severe leg weakness and deformation as they grow rapidly (Moyle et al., 2014). Nowadays, the parents stock is also kept in organic conditions in some rearing systems, which makes it possible to decrease the rearing period to (≥ 74 days), but high culling and mortality could still be a problem also when using the FG genotypes.

High mortality has been 10-14% when using FG hybrids in prolonged production periods, in contrary to using SG hybrids which had lower mortality in the same production system (Fanatico et al., 2008). Two different new Slow-growing (SG) hybrids, namely Rowan Ranger (RR) and Hubbard (H) have been introduced to the Swedish poultry organic production recently, however, the scientific data about these genotypes performance in Sweden are still limited.

The relation between housing conditions, management and animals is complicated, and it requires taking measurements directly on animals to evaluate this relationship. Yet, focusing on the natural behaviour and integrity of the animals in organic husbandry could establish a conflict with other health complications and problems like a high exposure to parasites, predation and welfare problems like the possible cold stress when using housing systems with an outdoor range (Berg, 2002).

A significant decrease in lying and resting behaviour has been noticed in the FG hybrid Ross 308 when reared in an alternative enriched system provided with an outdoor range area, perches, straw bales and pecking stone. The decrement was higher than what noticed in SG hybrid Ross Sasso in the same Alternative system (Bergmann et al., 2017). This could apparently indicate the importance of enrichments to increase the mobility and locomotion in less density raised birds and which in turn could contribute to better skeletal health and fewer injuries in hocks and footpads.

Additionally, Tuyttens et al. (2008) found that broilers that are raised in organic systems had longer latency-to-lie compared to birds in conventional systems and had furthermore better hock burns (HB) and footpad dermatitis (FPD) score, breast conditions and duration of immobility comparing to birds in conventional flocks (Bestman and Maurer, 2006). In another study conducted in Dutch broiler flocks, a significant effect of the months has been noticed, whereas March and December were always with high FPD score (de Jong et al., 2012), in the same study breeds has a significant effect on FPD, as Hubbard flex had the lowest score and Ross, especially males, had the highest score for FPD, however, the study by de Jong et al., 2012 was conducted on FG hybrids.

Since the organic broiler regulation requires long rearing periods (≥81 days) (European Council 2019; Krav 2019), it is very important to choose a suitable hybrid in these organic production systems. A comparison in health performance between two medium-growing (MG) and one FG broiler hybrids during a long rearing period showed that 92.7 % of the birds from the FG genotype Ross 308 had suffered from leg problems and acute joint inflammation at some time point of the study, similarly, leg weakness was reported to be the main reason for culling in FG and SG hybrids especially when fed with low protein diet (Rezaei et al., 2018). Additionally FG hybrid had a higher prevalence of Footpad dermatitis (FPD) and breast blister (BB) comparing to one of the medium-growing (MG) hybrids, however, FPD and BB were higher in the other MG hybrid study (Kabir KR4) which was used in the study by (Bosco et al., 2014).

Footpad dermatitis (FPD), Leg and joint problems strongly affect the mobility of the birds and cause lameness. A big variation in activity levels has been noticed between FG and MD hybrids, while MG hybrids spend much time at the outdoor range pecking and foraging, in contrary to FG hybrids, which spent longer periods crouching inside the farm (Bosco et al., 2014). A study by (Rutten et al., 2002) also showed that using a suspension device to alleviate and reduce the bodyweight load on birds led to longer travel distances, higher activity levels, better longitudinal growth of legs.

Lower locomotion activity in broiler was suggested to be combined with high growth rate and body weight in earlier period of life, which is found in FG broiler hybrids. To put it another way, the less the locomotion, the more the problems in bone development and deformation in broiler and even lower activity and walkability could lead to long sitting durations and causes skin and breast lesions (Bessei, 2006). Likewise, what it was proven, that increased activity in FG broilers leads to higher bone strength and fewer legs abnormality, where birds had the better walking ability and improved skeletal condition after 15 minutes training/4 times a day (Thorp and Duff, 1988).

Gait score is also an important indicator of welfare in broiler chickens. Kerstin et al., (2001) concluded that SG hybrids tend to have better gait score than MG and FG breeds and this agrees also with the findings by (Fanatico et al., 2008). However, it is well known that growth rate is highly genetically controlled and almost all breeding programs were aiming to use this feature to breed for higher growth rate birds, (Kestin et al., 2001) suggested that better gait score in SG hybrids could be a correlation between weight gain and not the genotype, in other words, the higher the daily weight gain, the more the lameness prevalence.

Growing fast during the rearing period and gaining heavier weight rapidly demands higher skeletal and bone strength to grants better mobility and activity levels during the broiler´s lifetime. SG hybrids have been suggested to have higher bone quality comparing to FG hybrids, taking into consideration the body weight and the load on legs. In addition to that, breaking strength and density of tibia was calculated to be higher in SG than FG hybrids, (Newman and Leeson, 1999; Shim et al., 2012).

The way to keep the growth rate in FG hybrids low as required in the regulations could be restrictive feeding, nevertheless, food restriction could be the main generator off redirected behaviours which transfer to stereotype animals like spot-pecking in poultry, which actually indicates a frustration and a sign of reduced welfare (Tolkamp and D'Eath, 2016). Furthermore, in severe cases hunger would lead to extreme feather pecking and cannibalism outbreaks (Cronin et al., 2018).

In a comparison between FG hybrid (Ross) and SG hybrid (Rowan Ranger) by (Rezaei et al., 2018), Rowan Ranger appeared to grow faster when fed on a high protein diet than a low protein one, in contrary to Ross where the growth rate was higher when fed with low protein diet, and feed conversion ratio was lower for Ross comparing to Rowan Ranger. Sticky dropping, which is a digestive excreta that sticks to the cloak, seemed to be a problem in FG hybrid (Ross) compared to SG hybrid (Rowan Ranger), especially in birds fed with high protein diet (Rezaei et al., 2018), the problem is mainly cause of that this dropping sticks to the feather and then the animal gets dirty plumage and it might even be irritating and painful to the animals to have excreta on the cloak.

Bokkers and Boer (2009) compared the economic and environmental impact of organic and conventional poultry production in the Netherlands, they stated that the economic performance of organic broiler production was better than the conventional production systems, however, this seemed to be very price and period-related and can differ in different circumstances. On the other hand, SG organic production had lower ecological performance, as this system emits higher amount of greenhouse gases and the feed conversion is lower for 1 kg organic chicken meat compared to conventional (Bokkers and Boer, 2009). Health indicators like Mortality were better in birds that grow slower regardless of the system, which gives an advantage for SG hybrids to maintain decent welfare levels than FG hybrids in conventional systems (Bokkers and Boer, 2009). Total carcass weight differs between different genotypes reared in organic and conventional production systems.

Usage of outdoor range for broilers in an organic system is still an argument between scientist and stockholders, whereas bird did not tend to use the outdoor range effectively even if they have access to it and if birds go outside they would stay very near to the house and not go farther (Rodriguez-Aurrekoetxea et al., 2014). Even though with increased complexity in house, SG hybrid Sasso T44 did not seem to be affected and encouraged to use the outdoor range, while only 4.5% of the total number has observed outside (Rodriguez-Aurrekoetxea et al., 2014).

On the other hand, temperature and increased older had a noticeable effect on the outdoor range usage, total travelled distance and number of animals observed in the outdoor range increased with higher temperature

(≥14°C and especially in later older week 9, 10 of age), nevertheless, this effect has not been noticed in earlier older (week 6, 7, 8 of age) (Rodriguez-Aurrekoetxea et al., 2014). Moreover, birds seemed to prefer areas with more trees and bushes over grass, and this indicates that birds prefer areas where they can seek cover under (like trees and bushes) and not wide open areas (Dawkins et al., 2003).

Another factor to consider is the pop holes in the house, whereas (Gilani et al., 2014) reported that the high outdoor percentage increased with increased pop holes in the house, the highest was 58% in small scale organic flocks. SG hybrids showed higher activity and better usage of the outdoor range comparing to FG ones, which rarely went outdoors (Fanatico et al., 2008). Weight gain, feed intake and efficiency or yield did not seem to be affected by access to the outdoor range, stated (Fanatico et al., 2005; Fanatico et al., 2008). Nevertheless, bone-breaking strength was significantly higher in birds raised with outdoor range access according to (Fanatico et al., 2005), which was In contrary to what (Moyle et al., 2014) later suggested that bone strength was not affected by outdoor range access in FG hybrids.

The first objective of the study was to compare two different SG organic hybrids, which has newly started to be used in Swedish organic broiler production, regarding weight production and welfare and health indicators using Welfare Quality® modified protocol, and then applies a performance comparison between these two hybrids using two different housing systems. The second objective of the study was to collect a large number of observations from different commercial organic farms which use the two hybrids of intresst in Sweden and then study the above mentioned welfare parameters in these farms separately.

2. Methods and materials:

This study is divided into two parts. Part 1 has been executed in a research centre belongs to The Swedish Agricultural University (SLU), and all procedures were approved by the national ethics committee with approval number 112-2015. Part 2 was a form of collected health and welfare observations from different local organic farms in Sweden, rearing the same hybrids of interest.

2.1 Part 1:

2.1.1 Animals and Housing systems:

400 broiler chickens from two different SG hybrids, 175 + 25 Aviagen Rowan Ranger (RR) and 175 + 25 Hubbard CYJA57 (H) were used. The birds from both genotypes were bought at one day old from a breeding company and reared until 10 weeks old. Two different housing systems have been used in this study. where the birds were housed in a controlled climate in two different types of pens with wood shavings litter.

175 birds from each hybrid (totally 350 birds) were housed together in one big pen (7.5X20 m, density 0.86 m2/bird) (see figure 1) with access to an outdoor range (4 m2/bird, in total 1400 m2) through two pop-holes which are opened usually between 8:00-18:00 hours. The indoor area was furnished with ten hanged plastic feeding troughs with 8 kg capacity/each and fifteen water barrel drinker with 10 L capacity/each placed on the ground, moreover, the area enriched with straw bales, access to Lucerne and A shape multileveled perches (at 20, 40 and 70 cm height, 15 cm/bird). The outdoor area was fenced and contained grass and different type of enrichments, four wood board (150X140 cm) and four nets (60X80 cm), which were used as protection from prey birds between the house wall and the fence.

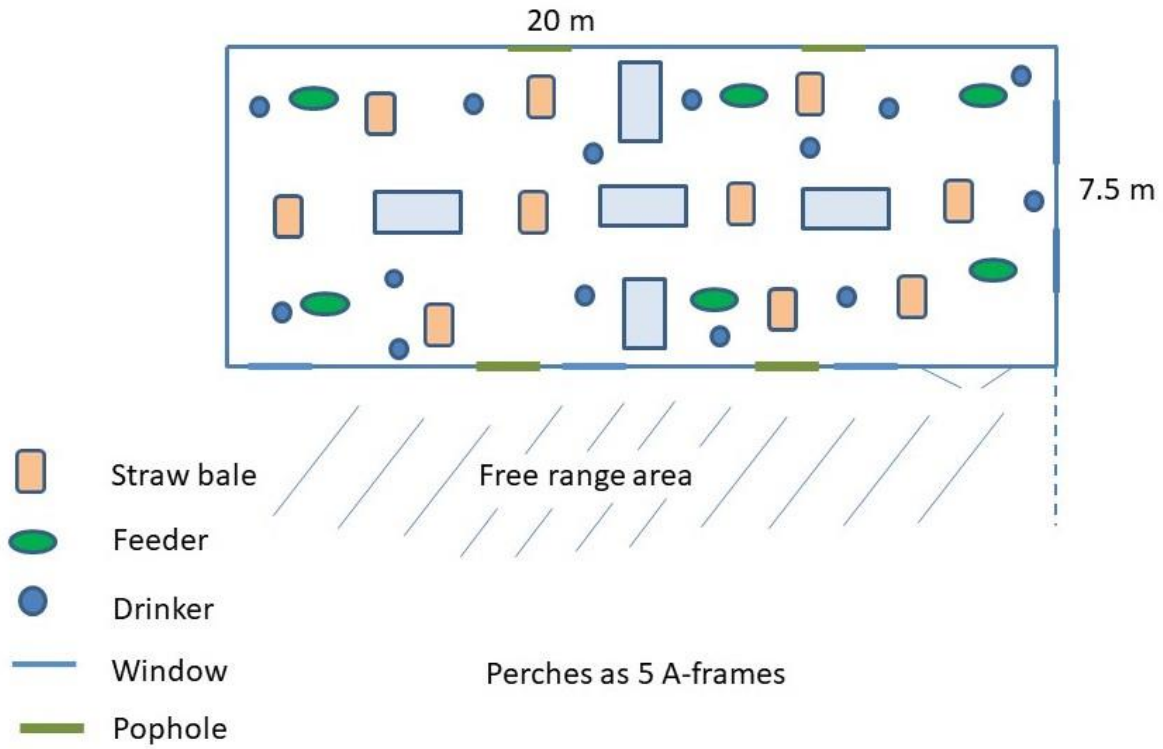


Figure 1: a sketch of the big pen design and enrichments

25 birds of each hybrid were also reared in 10 small pens (1X1.5 m, density 0.3 m2/bird) with 5 birds from the same hybrid per pen. Every pen had one feed trough with a capacity of 8 kg and one 10 L water barrel and was enriched with A-shaped perches with two levels (20 and 40 cm).

The Surrounding temperature was 33°C at the beginning of the study and decreased gradually to 23°C until the end of the study. Continuous lighting was provided at the first 24 hours and gradually decreased to 6 hours of darkness out of 24 hours on day 8 which remained constant until the end of the study. The windows were completely covered during the dark period to ensure full darkness, feed and water were offered *ad libitum*. In total, 14 birds were found dead and 9 birds were culled for different reasons during the study. All dead or culled birds were examined and dissected by a professional veterinary laboratory.

2.1.2 Samples and Data Recording:

Birds in both housing systems (small and big boxes) were caught carefully using light metal net fencing and thereafter gently examined. The welfare and health assessment were performed by using a modified Welfare Quality® (WQ) assessment protocol in poultry, while mortality and culling, skeletal problems, plumage cleanliness, footpad dermatitis, hock burns, gait, and skin wounds (see table 1) were recorded weekly in both housing systems.

Table 1: Welfare indicators which are used in the modifed welfare quality® protocol.

Welfare principle	Criteria	Welfare indicator	Assessment description
Good health	*Absence of disease*	Mortality and culling	The number of chickens which have found dead or culled were recorded continuously by mentioning the reason for culling and performing autopsy of the dead birds
		Plumage cleanliness	Recording the status of the feather in birds
	Absence of injuries	footpad dermatitis	FPD was assessed on each bird while lying on its back
		Hock burns	HB was assessed on each bird while lying on its back
		Gait	Gait was assessed by observing the birds individually while walking inside the pen
		Skin wounds	SW Were assessed by observing the bird from a distance

The following parameters were scored during the Health and Welfare Quality assessment: Plumage cleanliness (PC) on a scale from 0 (clean) to 3 (dirty), Footpad dermatitis (FPD) and Hock burns (HB) on a scale of 0 (no evidence of FPD or HB) to 4 (strong evidence of FPD or HB), and lameness by gait scoring on a scale from 0 (normal, dexterous, agile) to 5 (incapable of walking) (Welfare Quality®,. 2009). Additionally, three more indicators were recorded as follow: rectum cleanliness on a scale of 0 (clean) to 1 (dirty), skin wounds on a scale of 0 (no presence of skin wounds) to 2 (more than two skin wounds) and skeletal problems on a scale of 0 (no evidence of skeletal problems) to 1 (evidence of skeletal problems).

During the last week of rearing before slaughter, faecal samples were collected for Salmonella and Campylobacter testing. Salmonella samples were collected by pulling socks over the boots and walking through the whole barn. Then the socks were pulled off and packed in plastic bags. For Campylobacter sampling fresh faecal droppings were collected throughout the barn in plastic bags. All samples were sent to the Swedish National Veterinary Institute for analysis.

2.1.3 Bodyweight, slaughter weight and Mortality:

Bodyweight of all birds in each penpen was recorded once weekly during the experiment, weighting was performed on the same occasion when the WQ assessment was executed to reduce the stress and potential effect of handling on the birds. Dead or culled birds were recorded frequently during the study. On day 71, all birds were slaughtered by electric stunning and bleeding in a commercial abattoir. Whole Bodyweight and carcass parts weight were recorded directly after slaughtering.

2.1.4 Statistical analysis:

Modified Welfare Quality protocol was used to record several parameters in this study, data has been compiled on Microsoft Excel sheets. Statistical analysis was performed using Minitab 18 version 18.1 (Minitab 2017). Results are presented in mean value and considered to be significant if $p < 0.05$. Many parameters such as Breed, housing system, weekly weight gain, body weight, FPD, Plumage cleanliness and sex has been analysed. The effect of breed (fixed) on other responses like plumage cleanliness and Footpad dermatitis has been performed using logistic regression model. FPD and plumage cleanliness was scored on binary score (1-4), Housing system was included in the model. No interaction has been included between these variables.

Body weight in week ten and carcass weight between the two breeds were compared using Welsh two sample-t test.

Pearson Correlation has been used to estimate the correlation between different variants, such as breast meat yield and leg meat yield and its correlation with the housing system which was included as fixed effect and the activity levels in each breed.

2.2 Part 2:

2.2.1 Animals and housing systems:

This part of the study was executed as an epidemiological study of health and welfare observations in eight different organic broiler flocks, comprising almost 72% of all farms in Sweden. 400 birds were randomly selected from all flocks (50 bird/flock). The flocks had one of the hybrids of interest (Hubbard CYJA57 or Avigen Rowan Ranger).

2.2.2 Data recording:

The observations in this part took place on one occasion/farm. All assessments were recorded by the same person, but the order of the pens or farms was random. 50 bird/flock were carefully caught using light metal net fencing, weighted thereafter gently clinically examined to look for injuries on the head and comb, the plumage, body condition, the condition of the skin, particularly on the breast, the hocks and the footpads (Table 1). Examined birds were marked to make sure they were only caught and examined once. The parameters have the same description protocol as mentioned in Part 1.

2.2.3 Interviews with farmers:

Farmers in all commercial farms were interviewed to provide information about mortality, range size, vaccination and many other indicators which could be collected by oral interview.

3. Results:

3.1 Study Part 1:

3.1.1 Weight gain:

The growing rate between both hybrids was close with no significant ($p > 0.05$) (see figure 2), the variation in live weight was bigger in Hubbard (H) comparing with Rowan Ranger (RR). Nevertheless, there was a significant interaction between breed and live weight, where RR had higher live weight in week 10 (3123 ± 454) comparing to (3021 ± 444) in H, mean ± standard deviation P= 0.02, F= 4.93, N= 190, there were no significant differences in carcass weight in both hybrids after slaughter, see (figure 3).

On the other hand, live body weight in the first week of age was significantly higher in RR (79±7) compared to H (72±8) mean± standard deviation P=0.001, F=92.58, N=198, however, the total daily weight gain during the whole study period was close between both hybrids, (43,98 g/day) for RR and (42,54 g/day) for H.

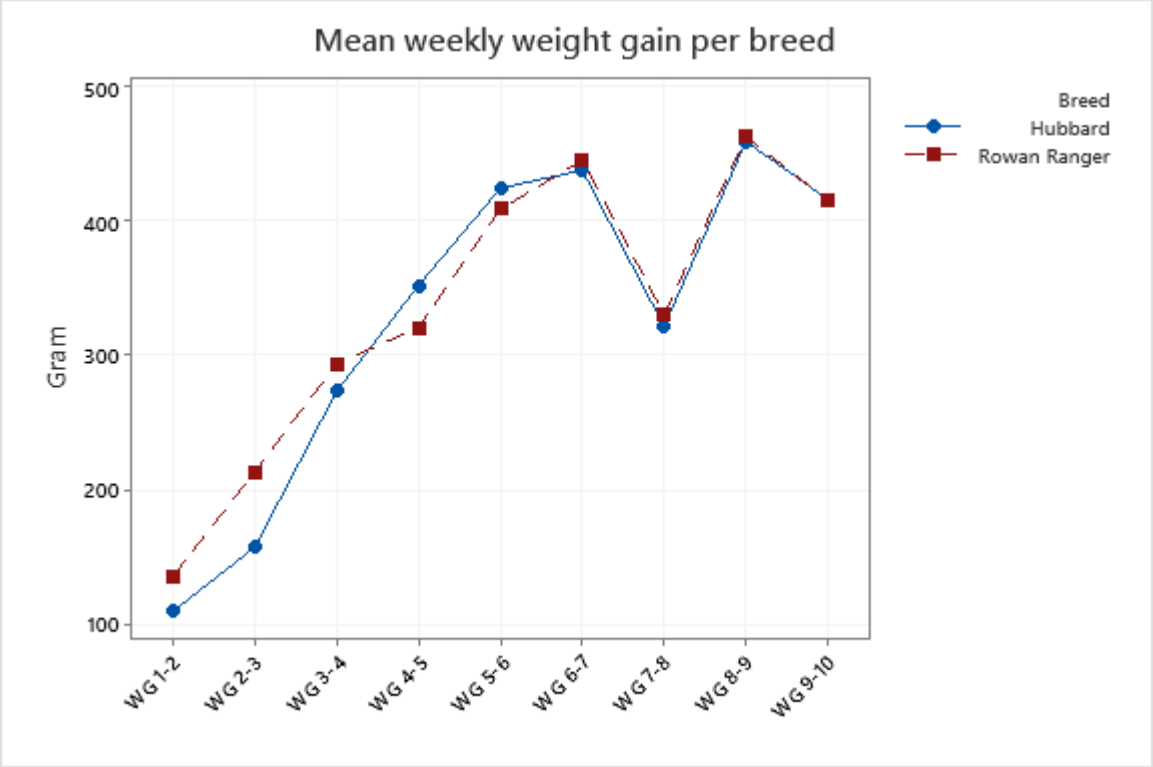


Figure 2: Mean weekly weight gain in g in different hybrids.

moreover, live weight in week 10 was significantly higher in birds in small boxes (3217 ± 450) compared to big boxes (3051 ± 448) mean ± standard deviation P= 0.01, F=5.82, N= 336.

It has been noticed that there is a decline in weight gain in both hybrids during week 7-8. No explanations could be found for that, as no changes have been made to the environment or the feeding system during this week. As both hybrids have shown this decrement, it could be strongly related to an environmental factor such as if the birds have been scare by some sounds or sunlight reflections from the surrounding area.

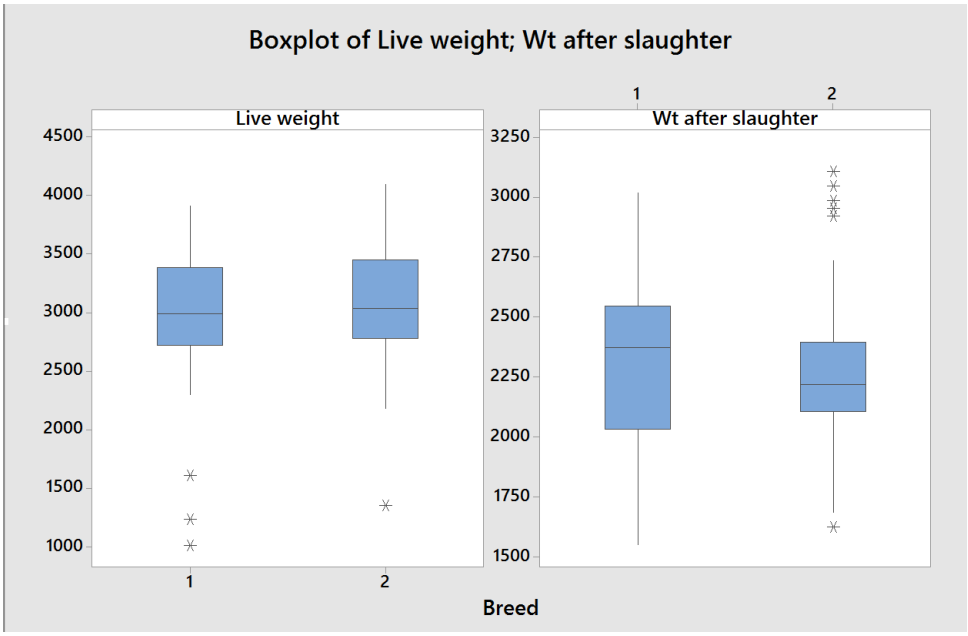


Figure 3: Live and carcass weight frequency in both hybrids.
1= Hubbard, 2= Rowan Ranger

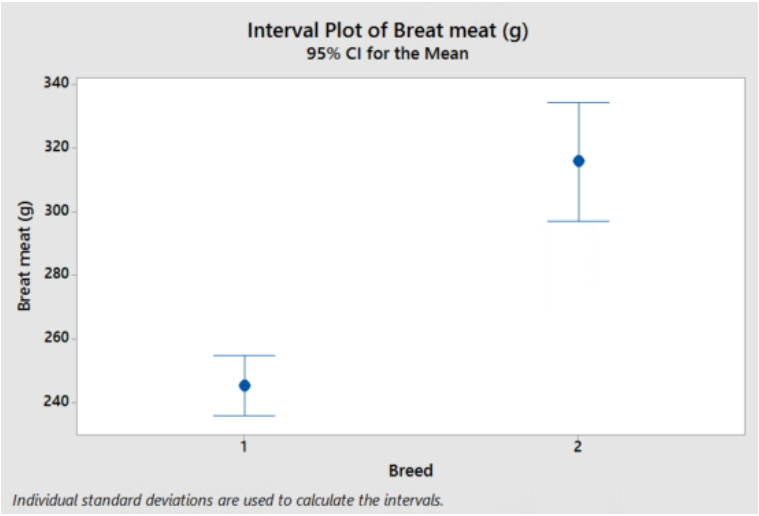
The gender had a clear significant effect on weight gain, whereas male birds had higher live weight in week 10 (3432 ± 304) compared to females (2785 ± 290) (mean± standard deviation). P= 0.001, F=448, N= 172, see (table 2).

Table 2: Gender impact on live body weight:

Treatment	Total number			Live body weight (mean)	
	N	Male	Female	Male	Female
RR small box	25	12	12	3683	3080
H small box	25	11	14	3360	2823
RR big box	175	70	98	3487	2805
H big box	175	79	84	3353	2718

3.1.2 Carcass parts weight:

By comparing carcass in birds, RR had higher breast muscle weight (316±61) and lower body fat (52±28) compared to H (245±32), (80±28), (P<0.001, F=47.68 N=46), (P=0.001, F=22.92, N=46) respectively (mean± standard deviation). Moreover, RR had a higher leg weight (312±54) comparing to H (289±50) (mean± standard deviation) P=0.04, F=4.28, N=46. See figure 4, 5. Using Pearson correlation has shown that there was a high correlation between carcass weight and breast muscle weight and leg weight (r= 0,757, r= 0,919 respectively). Contrarily, a negative correlation has been noticed between all variants and body fat.



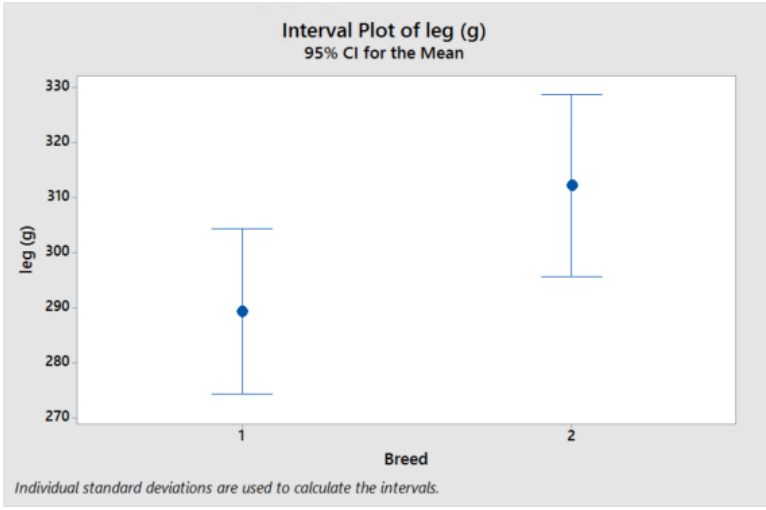


Figure 4: breast and leg weight frequency between hybrids
Breed 1: Hubbard, Breed 2: Rowan Ranger

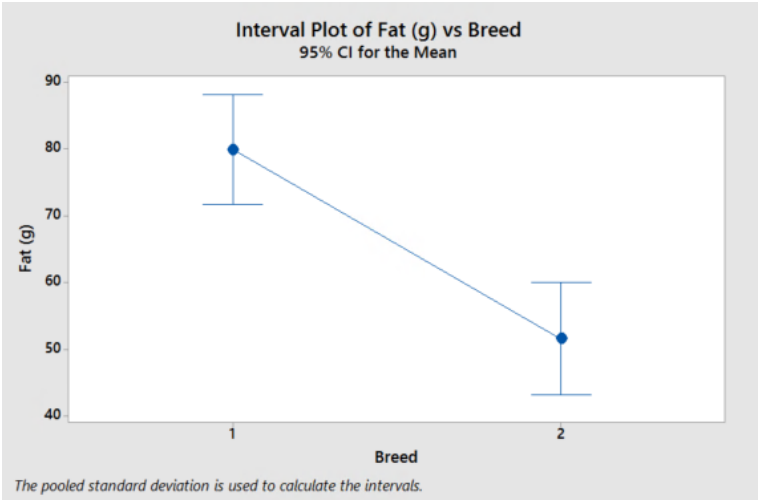


Figure 5: body fat amount in different hybrids
Breed 1: Hubbard, Breed 2: Rowan Ranger

The housing system did not have any effect on breast muscle weight, however, birds in big boxes tend to have heavier legs (313±55) and lower body fat (58±30) comparing to birds in small boxes (268±31), (85±24), (P=0.001, F=15.79, N=64), (P=0.001, F=16.30, N=64) respectively (mean± standard deviation).

3.1.3 Mortality and culling:

Mortality and culling were recorded continuously and was considerably low in both housing systems and hybrids. Totally, fourteen birds were found dead (7 H and 7 RR) and 9 birds (5 H and 4 RR) were culled because of different reasons. No interactions with the housing system or breed were found. All dead or culled birds were examined and dissected by a professional veterinary laboratory, 5 birds had oedema and lungs inflammation, 3 birds had some physiological changes in the liver and kidneys, 3 birds had ascites and enlarged heart, 1 bird had

hemorrhagic enteritis, 1 bird had enlarged crop, 3 birds had skeletal/legs problem, and 4 birds had no specific findings, (see table 3).

Table 3: dissection findings in birds:
Note: more than one finding can found in the same bird.

Treatment	N	Mortality		Liver inflammation	Lung inflammation/ Oedema	Ascites Enlarged heart	H. enteritis	Enlarged/constipated crop	Kidney inflammation	Skeletal/leg problems	No specific findings
		found dead	Euthanized								
RR small box	25	1	2	II	I	I					
H small box	25		1							I	
RR big box	175	5	1		IIII	I			I		I
H big box	175	2	5			II		I		III	II
RR mark missing	1	1									I
H mark missing	3	2	1				I				II

The calculated mortality was 0.05 % for H and 0.05 % for RR, and it was also very low in different housing systems (0.037% in big boxes and 0.08% in small boxes).

3.1.4 Welfare and health indicators registration:

Almost 10% of all birds had dirty plumage, while the dirt varied in location but mostly on the rectal area, and 1% had some type of mild footpad dermatitis (FPD), 12 birds out of 400 had a gait score 3, non-above. RR tends to have more incidents of dirty plumage (0.16±0.37) compared to H (0.01±0.1) (Mean ± standard deviation), P=0.001, F=32, N=198. Moreover, RR tends to have a higher FPD score (0.03±0.17) compared to H (0), P=0.01, F=6.09, N=195. Additionally, birds in small boxes had significantly higher incidents of plumage cleanliness (0.28±0.45) comparing to the big box (0.06±0.23), P=0.0001, F=28, N=25, here we shall take into consideration the sample size, whereas it was just 50 birds in small boxes comparing to 350 in big boxes. Neither sex nor skeletal/leg problems had any effect on these parameters. No Hock burns, skin wounds, breastbone deformation or crops problems were observed on the birds. No presence of Salmonella or Campylobacter has been found in all samples taken from birds during the rearing period.

3.2 Study Part2:

3.2.1 Health and welfare observations:

After collecting observation from 8 different organic commercial farms, H tends to have a higher FPD score (0.35±0.56) comparing RR (0.16±0.36) P=0.0001, F=15.94, N=150 (mean± standard deviation). On the other hand, H showed better plumage cleanliness (0.36±0.53) than RR (0.79±0.67) P=0.0001, F=43.36, N=150 (mean ± standard deviation), see figure 6, 7.

Gait score was also observed and registered randomly in commercial farms, yet, almost all farm had a good gait score register (2/5 and less), except 12 birds in two different farms with a gait score 3/5.

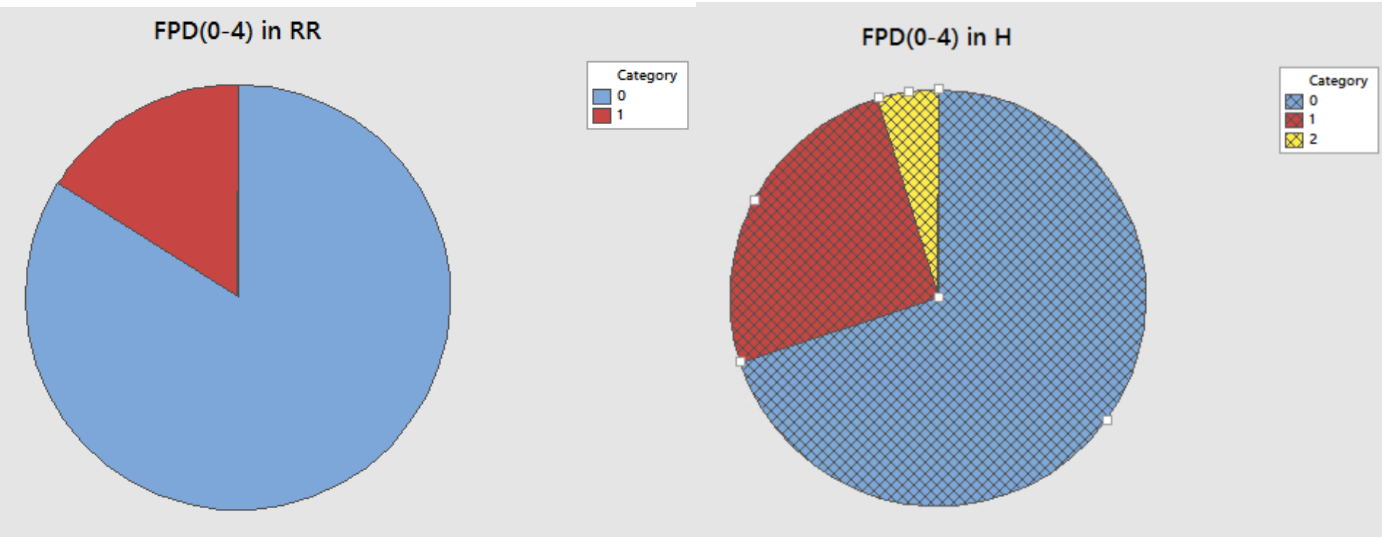


Figure 6: FPD (0-4) in hybrids in commercial farms

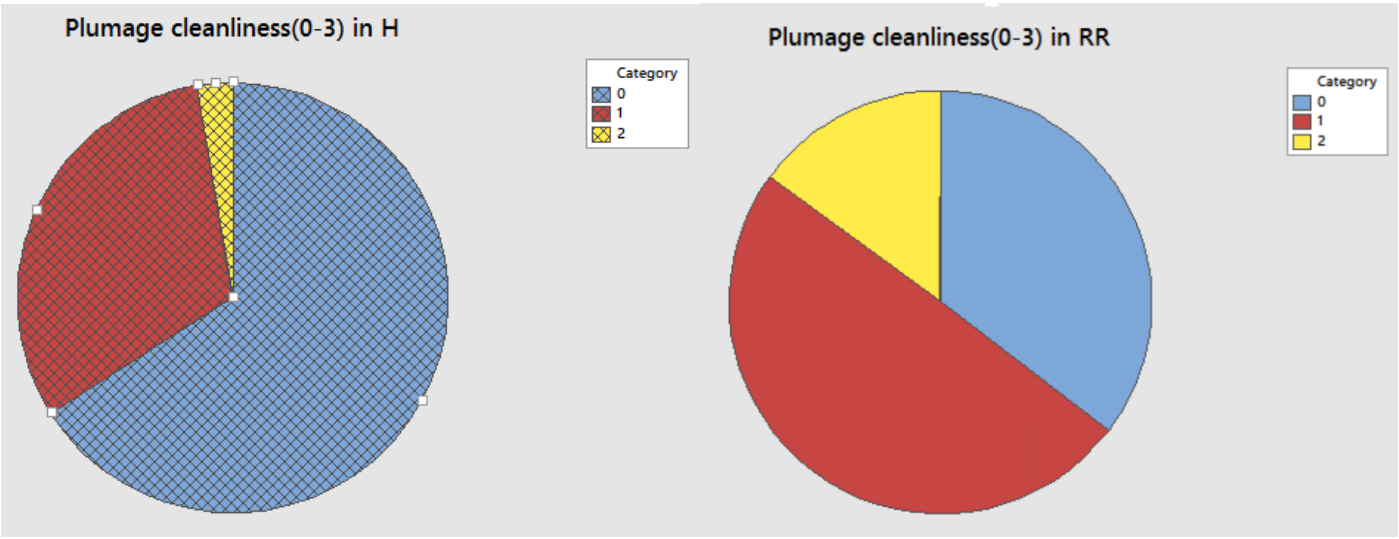


Figure 7: Plumage cleanliness (0-3) score in hybrids in commercial farms

3.2.2 Mortality and vaccination:

In this part of the study the mortality was not calculated statistically, but taken from oral interviews with the farmers. The mortality varied from 3-8% in most of the farms. Moreover many farms did not use any vaccination for their flocks, see table 5 for more details.

3.2.3 Capacity and usage of the outdoor range.

The range area varied between different farms, where some farms had a smaller range (2 m^2/bird) than others (up to 5m^2/bird), nevertheless, usage of the range was considerably low in all farms except one farm which had almost 21% of its birds in the outdoor range during the observation. See table 4.

Table 4: observations in commercial organic farms

Farm	Flock size	Hybrid	Age (Days)	Mortality %	Range capacity M2/bird	TEMP when observation	Birds outside %	Target weight g	Vaccination
Farm A	4800	H	57	3-4%	2	9,5°C	1	2900	Paracox Sometimes, Gumboro in outbreaks
Farm B	4400	RR	48	3-4%	2.2	8,3°C	0	3000	No vaccination
Farm C	4500	RR	NA	5-8%	4	10,2	6	2800	Paracox
Farm D	10600	RR	58	3-4%	NA	8,6	21,5	2500-2800	Paracox
Farm E	9888	H	44	3-4%	2	12,2	3	3000	Paracox
Farm F	9600	RR	57	5-8%	2	16,8	1,1	2700-2800	No vaccination
Farm G	4500	RR	10	5-8%	NA	7,5	0	2000	No vaccination
Farm H	8000	H	55	5-8%	5	12,2	0,2	3000	Gumboro and paracox

3.2.4 Hatching in farm and arrival room

5 farms out of 8 use hatching in farm and all farms are using a small reception room to have the chicks at the beginning of the production cycle and them moving birds to the bigger house on 20-25 days old. Most of the farmers thought that it was much difficult to use hatching on farm because it generates a lot of work, see table 5.

Table 5: Hatching and arrival room:

Farm	Flock size	Hybrid	Hatching in Farm	Arrival room	Age when moving to house (Days)	Mortality %
Farm A	4800	H	NO	YES	21	3-4%
Farm B	4400	RR	YES	YES	20-21	3-4%
Farm C	4500	RR	YES	YES	21	5-8%
Farm D	10600	RR	YES	YES	21	3-4%
Farm E	9888	H	NO	YES	20-23	3-4%
Farm F	9600	RR	YES	YES	20	5-8%
Farm G	4500	RR	YES	YES	21	5-8%
Farm H	8000	H	NO	YES	20-25	5-8%

3.2.5 Activity level:

By observing activity levels in birds and registration of the percentage of birds that are walking, sitting, flying and running in the 8 commercial farms, ANOVA analysis could be conducted to see if a breed was significantly more active than the other. There was a minimal difference between the two hybrids in activities like walking and sitting with no significant (p=0,595 and P=0,064 respectively). However, H tends to run significantly more than RR (p=0,046). No birds were flying during the observation sessions in all farms.

4. Discussion:

There was a big variation in finishing live weight between both hybrids (Rowan Ranger and Hubbard) (3123 ± 454), (3021 ± 444) respectively, however the weekly and daily weight gain was similar between them except the first week of age where RR had higher weight (79±7) than H (72±8) and this could be explained by taking the variation between egg weight and parents age when hatching in consideration, though, RR broiler parents

were 42 weeks old and had egg weight (61.4g) before hatching and H broiler parents were 30 weeks old and had lower egg weight (55.1 g) before hatching. So based on this, the variation of weight gain in the first week could be due to the effect of the start weight of chicks.

Despite the fact that the mean carcass weight was very close between hybrids, its frequency was wide especially for H and which could affect the homogeneity of the flock, but this could possibly be explained by the gender effect, since there were big differences in live weight between males (3432 ± 304) and females (2785 ± 290), and male were significantly heavier than females when slaughtering. And this also agrees with the general findings by (Fanatico et al., 2008, 2005).

Using different genders, the differnse in parensts age and egg weight in part 1 in the study could affect the study´s resulta regarding carcass weight negatively and this would affect the conclusion. Using standarised samples could generate higher accuracy in the studies results.

Furthermore, RR showed significantly better breast meat yield, higher leg yield and even lower body fat (316±61), (313±55), (58±30) respectively, comparing to H (245±32), (268±31), (85±24) respectively, and based on these findings we could with high likelihood conclude that these differences are mainly caused by genetical factors. Higher breast and leg yield would make RR a favourable by some stockholders. Generaly, both hybrids showed that they are good alternatives for organic broiler production, through having an optimum daily growing rate so near to 45g/day which is a requirement for organic production in Sweden (European Council 2019; KRAV 2019).

What´s more, birds in small pens had higher live weight comparing to bids in the big pen, nevertheless, birds in the big pen had higher leg weight and lower body fat compared to birds in small pens, and this could be explained by the higher level of birds´ activity between these two different housing systems, where birds in the small pens had fewer enrichments and moving space comparing to birds in the big pen which had access to an outdoor range, straw bales and perches.

Mortality in part1 of our study was considerably low and there was no effect of the housing system or genotype on it and this agrees with the conclusions of (Moyle et al., 2014); Fanatico et al., 2008; Bokkers and Boer, 2009). Lung oedema, ascites, skeletal/leg problems, liver inflammation were the most common findings.

Using mortality in part 2 of the study could not be possible because mortality in the commercial farm was recorded based on estimation by farmers with inadequate documentation, furthermore, many factors which could affect mortality like vaccination and predation could not be studied in these farms. Better documentation routine would contribute to a better understanding of the cause of mortality in birds in commercial farms.

Welfare quality observations have varied a lot between hybrids, forasmuch as RR had considerably higher FPD and worse Plumage cleanliness which can possibly be explained by higher dustbathing rate, yet, no differences in dustbathing were observed between both hybrids. On the other hand, H tended to have higher FPD than RR in commercial farms.

Many factors could affect FPD such as season, higher FPD in December according to (de Jong et al., 2012), depopulation method (thining), litter quality, stocking density, leaking drinkers, very small/big amount of litter. Many of these factors were not covered by the study and even inapplicable for these commercial farms, which would cause som magnifying this incidens of this parameter in some commercial farms comparing to others.

Possible explanations for higher differences in FPD cases could be management factors like leaking drinkers, improper litter amount and even the season, which was October for all farms except for one, the humidity could affect the litter quality and cause higher FPD.

The worse plumage score in small pens can be explained by the shorter distance between perch, feeder and water barrel and the inability to sleep on higher than the ground level for some birds, and this could also show the advantage of the enrichment in big boxes and the presence of outdoor range. Gait score was also very good in all commercial farms, thus, out of all observed birds, there were only 13 birds with gait score 3/5.

Enlarged and constipated crop in birds with access to roughage is usually a problem, however, in this study, no such cases were observed neither in commercial farms nor in the experimental flock. And the clinical examination of birds in commercial farms did not show any remarks regarding hock burns or skin/comb wounds. This could be a good indication that using environmental enrichment would contribute to better employment effect on birds and fewer pecking problems between them.

The utilization of the outdoor range has varied a lot between both hybrids and even the same hybrids between farms. There are many confounding factors such as predators, the birds' desire to stay near feeders and drinker inhouse, as observed by (Arnould and Faure, 2003), etc. Attacks by predators cause fear and birds refuse to go out after several attacks which leads to worse utilization of the range, as experienced by many farmers. Although all farms had a good vegetation level in their range, usage of the outdoors range varied a lot between farms and was considerably low in all farms except one farm. On the other hand, it is good to mention that usage of the outdoor range might be affected by many factors, like complexity inhouse, pray and predation attacks, weather, wind and temperature outdoors. More studies are required to understand the best way to encourage birds to go out and utilize the outdoor range better.

Birds in the commercial farms have minimal differences in activity levels, nonetheless, H had higher running activity comparing to RR. It is good to mention that the observation period was during a short time, which may not reflect the real activity levels in these birds during the rest of the day. Using activity meters for instance or even prolonged observation sessions would have given more detailed information regarding the different activity levels in both hybrids.

The variations and differences in several parameters between both hybrids could not have any direct and considered impact on the welfare of the birds because the variations in welfare Quality observations were minimal, however, differences in performance and carcass weight would eventually affect the insight of stockholders whom usually are also interested in higher performance combined with good welfare, hence higher performance means higher benefits at the end of a production cycle.

Almost all commercial farms which were included in this study has been using hatching in the farm. This approach could be very broiler friendly, as it exposes the bird for less transportation and handling stress and might assure a good start after hatching on the floor of the farm instead of the hatchery. Not to mention that all of these farms use the arrival room technique and were satisfied with using less space when receiving chicks, and this is a good innovation as it contributes to less energy using, better start for the chicks and even less cost for the farmer.

Using different hatching strategies, not using a standard vaccination program and even having different range cappacity in part 2 study could cause some difficulties in interpretation of the study result between both hybrids.

The study could concludes that there are many welfare advantages of using slow growing hybrids such as Rowan Ranger and Hubbard, however, more detailed studies on the outdoor range are required for better understanding and facilitating of the recourses. Very minimal health issues were observed during the study. RR has shown to give favourable production performance, thus had higher susceptibility to health problems, however, focusing on improving and provide a good environment would make RR a potential and competitive hybrid in the SG hybrids market.

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