Placement of enrichment and its impact on the distribution of hens in the outdoor run

Placering av skydd och dess påverkan på värphönsens spridning i rasthagen

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Abstract

The majority of the organic egg producers in Sweden are certified according to the rules of the organisation KRAV, who have stricter directions than the legislation of the European commission. In 2013, KRAV decided to clarify the rule on use of the outdoor area to ensure a maximum utilization of the offered area. This was met with dissatisfaction among many egg producers who saw great difficulties in encouraging hens to move around the entire pasture area. As a response, KRAV formed a project group to investigate different methods to increase the hens' utilization of the outdoor run. This master thesis was included in the project with the purpose to compare how two different arrangements of the same type of artificial enrichment affected the distribution of the hens on the range.

The experiment was conducted on four organic egg farms in Östergötland county in Sweden during April and May in 2015. In one paddock on each farm, two arrangements of enrichments were set up. Each arrangement consisted of eight tin roofs with four wooden legs and eight big straw bales. In one arrangement the enrichment was placed in a line with a straw bale and thereafter a roof and so on. In the other arrangement one roof was paired with a straw bale and these pairs were placed in a zigzag formation with ten meters in diagonal from each other. The 30-meter empty area between the two arrangements of enrichment functioned as a control area.

The enriched areas attracted more hens than the control area but the difference between the two arrangements of enrichment was not as clear. The zigzag arrangement seemed to be more favourable, with a higher number of hens than the line formation, but the result was not statistically significant and differed between farms. Hens moved further out within the enriched areas, but usually no more than 35 meters, with only a few hens as far out as 50 meters on a few occasions. Due to other parameters such as weather condition and differences in paddock design between farms it is difficult to draw a conclusion of which one of the arrangements is more preferable than the other. As found in several earlier studies, there are indications in this study that enriched areas attract more birds compared to areas with no enrichment.

Keywords: *poultry, hens, free range, enrichment, shelters*

Sammanfattning

Majoriteten av de svenska ekologiska äggproducenterna är certifierade enligt organisationen KRAVs regler vilka är striktare än den lagstiftning som återfinns i de europeiska förordningarna för ekologisk produktion. År 2013 beslutade KRAV att skärpa reglerna för ekologiska KRAV-höns utevistelse genom att öka kravet på deras utnyttjande av hela hagen. Den nya regeländringen fick stort motstånd från äggproducenterna som upplevde stora svårigheter att leva upp till det nya kravet att få sina höns att röra sig på hela den givna ytan. För att möta denna kritik satte KRAV samman en projektgrupp med uppgiften att finna metoder för att öka hönsens vilja att utnyttja hela hagen. Det här examensarbetet ingick i projektet med syfte att undersöka om placering av en viss typ av artificiell berikning kunde öka distributionen av hönorna. Likadana skydd placerades på två olika vis i hagen och därefter bedömdes vilken av dessa uppställningar som attraherade flest höns och fick dem att röra sig längst ut i hagen.

Försöket genomfördes på fyra ekologiska värphönsgårdar i Östergötlands län i Sverige i april och maj månad under år 2015. I en hage på varje gård placerades skydden på två vis med åtta plåttak med fyra träben och åtta storbalar av halm i vardera uppställningen. I den ena uppställningen stod skydden i en lång linje med varannan halmbal och vartannat plåttak. I det andra arrangemanget placerades ett plåttak i par tillsammans med en halmbal. Dessa parvisa berikningar placerades i ett sicksack-mönster med tio meter i diagonal från varandra. Det tomma området mellan de båda uppställningarna med en bredd på 30 meter fungerade som kontroll.

De berikade områdena tenderade att attrahera fler höns än kontrollområdena men skillnaden mellan de olika placeringarna av skydd var inte lika tydlig. Sicksack-formationen verkade mer fördelaktig med ett större antal höns jämfört med linjeformationen men resultatet var inte signifikant och skiljde sig mellan gårdarna. Hönsen förflyttade sig längre ut inom de berikade områdena men sällan längre än 35 meter. Endast ett fåtal höns gick 50 meter ut. På grund av andra parametrar så som väder och skillnader i hagarnas utseende, är det svårt att dra en slutsats om vilken uppställning av skydd som är mer gynnsam än den andra. I likhet med tidigare studier fanns indikationer på att berikning i hagen attraherar fler höns att gå ut jämfört med hagar utan berikning.

***Nyckelord**: höns, ekologisk, hage, berikning, skydd*

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1 Introduction

The demand for organically produced eggs in Sweden has increased rapidly during the last years and consequently the number of organic egg producers. The total number of laying hens was 6 873 700 in 2013 (Jordbruksverket, 2014a). Of these 868 378 were organic, which corresponds to 13 % of the total number of laying hens. In 2009 there were 579 015 organic hens so there has been a 50 % increase during these four years (Jordbruksverket, 2013a).

In 1995 Sweden became a member of the European Union (EU) (Europeiska unionen, 2014) and thereby a part of the Common Agricultural Policy (CAP). The purpose of the policy is to make agriculture more efficient, create an adequate standard of living for farmers and to stabilize the market, which is accomplished through intervention prices and agricultural funding (Jordbruksverket, 2014b). The members of the European Union follow a common agricultural legislation with special directives for organic egg production. Examples of these directives are that 95 % of the feed should be organically produced whereof 20 % produced on the farm, pullets must be organically reared, each building compartment shall have a maximum of 3000 hens with a maximum of six hens per square meter, hens shall have access to an outdoor run with shelters and the pop-holes need to be at least four meters per 100 m^2 of the indoor area (Jordbruksverket, 2014c).

In Sweden most of the organic egg producers are members of the organic certification body KRAV that has even tougher requirements than EU. Some of these requirements include that hens shall be given KRAV-certificated feed of which 50 % must be produced on the farm; have access to root crops or forage to peck at, sand to dust bathe in and the farmer should have a planned health promotion that is not routine preventive (KRAV, 2014a). In December 2013 KRAV decided to change the rules about the use of the outdoor runs to ensure a maximum utilization. The changes included that an area of four m^2 per hen needs to be available within 150 m from the nearest pop-hole. If the farmer can demonstrate that the hens utilize the total outdoor run it is permissible that the area of four m^2 per hen can occur within 250 m from the pop-hole. During a transitional period until 31 of December 2015 it is accepted that the hens have access to an area of four m^2/hen within 350 m from the pop-hole (KRAV, 2013).

As a result of the rule change there have been complaints from many egg producers who find the new requirements hard to fulfil and the major difficulty is for the farmers to encourage the hens to use the whole outdoor area. As a response, KRAV formed a project group with Malin Lovang as project leader and Åsa Odelros as supervisor to investigate different methods to increase the hens' utilization of the range.

This master thesis was included in the project and financed by Bertebos stiftelse. The purpose was to evaluate if the placement of the enrichment in the outdoor run has any impact on the distribution of the hens in the outdoor run. The trial was conducted on commercial farms and the same type of enrichment was placed in two different ways on each farm. The method was a quantitative behaviour study to determine which of the arrangements attracted most hens and encouraged them to move furthest in the outdoor run. There are several factors that can influence the utilization of an outdoor run such as design and placement of shelters, pop-hole dimensions, flock size, age of the hens when first given access to the outdoor area, hybrid and quality of the plumage. These aspects are included in the master thesis through a literature review and their impact on the use of the outdoor run is discussed together with the result of the trial.

2 Literature review

In organic egg production hens should have access to an outdoor run during at least one third of their lifetime and be able to forage (KRAV, 2014b). The purpose of the range is to increase the possibility to perform behaviours such as exploration and foraging and thus increase animal welfare. The outdoor run increases available space and lowers the density in the poultry house.

The advantages with an outdoor run are many, but the number of hens outdoors is often very low, being only a small percentage of the total population (Hegelund *et al*. 2005; Gilani *et al*. 2014). There are differences between individuals and some hens never enter the range on a daily basis (Icken *et al.,* 2008; Gebhardt-Henrich *et al*., 2014). Some individuals stay outside during the total opening time while others only allow themselves a quick visit and some hens never go out during their whole lifetime (Icken *et al.,* 2008). Some hens move in and out of the poultry house several times during the day and those that have once visited the range seem to continue to go outside on a daily basis showing the importance of familiarisation (Icken *et al.,* 2008).

With support from earlier studies, in this section several factors that influence the use of the outdoor run are highlighted. They are discussed together with the results from the trial in the last section of this master thesis.

2.1 Enrichment in the outdoor run

The laying hen hybrids used in modern egg production originate from the red jungle fowl (*Gallus gallus*) in Asia. The red jungle fowl's natural habitat is a tropical environment with vegetation and trees (Collias and Collias, 1967) that is very different from many of the outdoor runs in modern organic egg production systems. To increase the attractiveness of the outdoor run it needs to be enriched to be more similar to the hens' natural environment and to meet their behavioural needs. Poultry are prey animals with both aerial predators and predators on the ground and therefore seek security in trees or underneath covers.

2.1.1 Artificial shelters

Many studies have investigated the importance of enriching the range with artificial shelters to attract more hens to use the outdoor area (see Table 1) and most of the authors, except Zeltner and Hirt (2003), have seen a positive correlation regardless of what type of shelter was offered. Nagle and Glatz (2012) enriched the outdoor run with shade cloth which increased the number of hens to 43 % compared to 25 % in the control group and three times more hens used the shaded area compared to areas without shade. Hegelund *et al.* (2005) increased the number of hens on the range by enriching the outdoor area with several small tents with a diameter of 2.5 m and a height of 1.2 m, but the presence of hens outdoors was only eleven percent with enrichment and nine percent without.

Table 1. *Results of enriching the range with artificial shelters*

Type of enrichment	% of hens in trial range	% of hens in control range
[1] Trial Roofed boxes with sand: 210 x 110 cm 2 boxes placed 68 m from the openings Control No enrichment	On average 22.5 % No significant difference	On average 21.5 %
[2] Trial Waterproof shade cloth on four posts 10 and 20 m from the poultry house Control No enrichment	Morning: 43.2 % Afternoon: 30.7 %	Morning: 24.7 % Afternoon: 40.2 %
[2] Trial Waterproof shade cloth (average 35 m^2) fixed on 4 posts Located 30 and 60 m from the poultry house Control No enrichment	Six times more hens than control	Six times less hens than trial
[3] Trial Dome shaped tents: 2.5 m in diameter and 1.2 m in height, 1 tent/ 50 hens Starting 20 m from the poultry house Control No enrichment	On average 11 %	On average 9 %

[1] Zeltner and Hirt (2003)
[2] Nagle and Glatz (2012)
[3] Hegelund *et al.* (2005)

Shelterbelt is a way of placing shelters in a long row. This often functions as a windbreaker and is a commonly used enrichment in ranges for laying hens. In Table 2 several studies that have used different types of shelterbelts are shown. Borland *et al.* (2010) used shelterbelts consisting of trees in pots with different heights and saw a significantly higher percentage of hens outdoors with these structures compared to when there was no enrichment. Nagle and Glatz (2012) also used shelterbelts consisting of pots with trees or shrubs and saw a 17 times increase in the number of hens on the range compared to without enrichment. Rault *et al.* (2013) compared the impact of 18-meter long vertical structures with empty control areas and found that there were five times more hens close to the structures than in the control area.

Table 2. *Results of enriching the range with shelterbelts*

Type of enrichment	Hens in trial	Hens in control
[1] Trial Shelterbelts: shrubs in pots 6 m^2: 3 m x 2 m 10 and 20 m from the poultry house Control No enrichment	Morning: 40.8 % Afternoon: 45.4 %	Morning: 22.1 % Afternoon: 27.6 %
[1] Trial Shelterbelts: shade areas between 15-30 m^2 Located 15 and 30 m from the poultry house Control No enrichment	17 times more hens than control	
[2] Trial Trees in pots with heights 1, 2 or 3 m Shrubs in pots with height of 1 m Located 10 and 20 m from the poultry house Control No enrichment	On average 67.4 %	On average 52.3 %
[3] Trial Two parallel 0.8 m high fences, 1 m apart, starting 1 m from winter garden, 16.4 m long with 0.7 m gaps after each 5 m Control No enrichment	* On average 0.2 %	* On average 0.04 %

[1] Nagle and Glatz (2012)
[2] Borland *et al.* (2010)
[3] Rault *et al.* (2013), * Numbers are modified, see calculations in Appendix 1

Not only do the farmers want to increase the number of hens using the range, it is also important to increase the distribution of hens over the total outdoor area. In the study by Rault *et al.* (2013) the authors also compared how far out the hens would go when enriching the range with 18-meter long vertical structures and found that hens in the control area only went six meters out in the range. Near the vertical structures the hens instead moved up to 18 meters, indicating that the structures encourage them to move as far out as there was protection. The vertical structures consisted of three different materials with the thickest and less light permeable material at the part closest to the poultry house. Most hens stayed close to the vertical structure with the thickest material and the authors suggested that this material was more attractive than the other thinner and light permeable materials (Rault *et al.*, 2013).

Borland *et al*. (2010) could also see hens moving further out on the range with shelterbelts compared to no enrichment and Dawkins *et al.* (2003) saw an increased tendency for birds to move further out in the range when it was enriched with bushes and trees compared to only containing grass.

2.1.2 Natural enrichment

According to the organic legislation in the EU the range shall be covered with vegetation that provides the hens with the possibility to forage (Jordbruksverket, 2014c) and access to pasture on the range has been shown to increase the attractiveness for hens (Nagle and Glatz *et al.*, 2012). The type of vegetation used in the outdoor run therefore needs to be both attractive and

also resistant and viable. Soft leaf blades increased the pecking behaviour towards vegetation among the hens in a study by Breitsameter *et al.* (2014), especially in the presence of the swards *Agrostis stolonifera* L. Barifera, *Poa pratensis* L. Julius and *Poa supina* Schrad. The sward degradation increased with increased stocking period and by that a reduction in pecking behaviour. The plant *P. supina* was the most tolerant herb and received the highest number of pecks from the hens.

By enriching the range with vegetation the number of hens outdoors could be increased (Table 3). Nagle and Glatz (2012) offered hens access to pasture with sorghum or enriched the range with hay bales and saw an increase of 17 and eight times respectively compared to a control range. In another trial with wheat or vetch pasture compared with no pasture the control area had a higher percentage of birds during the morning, but in the afternoon the percentage of hens on the pasture enriched range were higher than the control. Dekker *et al.* (2012) saw a higher percentage of hens outdoors when the range was enriched with bushes and trees. This supports the work of Mirabito *et al.* (2001) who showed that broilers preferred a range with tall vegetation such as trees, corn and weeds. Even the length of the grass was important, with higher grass being more favourable than lower (Bubier and Bradshaw, 1998).

Table 3. *Results of enriching the range with vegetation*

Type of enrichment	**% of hens in trial range**	**% of hens in control range**
[1] Trial: Bushes and trees Control: No enrichment	13 %	1.7 %
[2] Trial: Forage: Vetch and wheat pasture Control: No forage	No difference on time: on average 45 %	Morning: on average 54 % Afternoon: on average 30 %
[2] Trial: Forage: Sorghum or hay bale Control: No forage	Sorghum: 17 times more hens than control Hay bale: 8 times more hens than control	
[3] Trial: Trees and bushes Control: No enrichment	More birds in the range, no percentage were given	Less hens in the range No percentage were given
[4] Trial: Peach tree orchards Control: No enrichment	** On average: 60.7 %	** On average: 13.4 %
[5] Trial: Tall grass Control: Short grass	Tall grass: on average 42.1 %	Short grass: Between 5.1 - 11.1 %

[1] Dekker *et al.* (2012)
[2] Nagle and Glatz (2012)
[3] Dawkins *et al.* (2003)
[4] Mirabito *et al.* (2001) ** Numbers are modified, se calculations in Appendix 2
[5] Bubier and Bradshaw (1998)

2.1.3 Impact of design and number of enrichments

As previous stated, the impact of shelters in the range has been investigated several times, but there have been few trials comparing the design or number of shelters. Bestman and Wagenaar (2003) could see an increased number of hens in the outdoor run with an increased number of covers but Zeltner and Hirt (2008), on the other hand, did not find any difference in the percentage of hens on the range when offering five shelters compared to only one. They did however see an increased movement among the hens, which indicates that the number of shelters has an impact on birds' exploratory behaviour. The hens also went outside earlier in the day, which suggests that access to more shelters decreased their fear levels.

Zeltner and Hirt (2008) also compared broilers' use of ranges enriched with a two-level perch, a pecking-tree, fir-cones, two fir-trees and shelters with a range with only simple structures and saw a higher number of hens in the range with the more complex structures (Table 4). Rodriguez-Aurrekoetxea *et al.* (2014) also enriched the range with perches or vertical panels as windbreakers but did not see an increase in the outdoor use (Table 4). The authors, however, believe that this could be due to that the perches were placed too close to the pop-holes and that the vertical panels were too unstable in their structure and moved when the weather was windy which was probably daunting for the birds. The average outdoor use was, however, over all very low and more than 60 % of the broilers never entered the outdoor area. When Nagle and Glatz (2012) offered pasture or hay bales to laying hens they did see a higher number of hens in the range compared to when it was enriched with shelterbelts or shade cloths.

Table 4. *Percentage of hens outdoor when enriching the range with a number of shelters or objects other than shelters*

Type of enrichment	**% of hens in trial range**	**% of hens in control range**
[1] Trial 9 vertical panels: Pipes with plastic green mesh, 0.5 x 0.5 m Control No enrichment	No significant difference	No significant difference
[1] Trial 9 perches: 50 cm long and 25 cm high Placed parallel to the pop holes Control No enrichment	No significant difference	No significant difference
[2] Trial Five shelters (covering 5 % of the area) Control One shelter (covering 1 % of the area)	Five shelters On total average 32.1 % Morning: 32.2 % Afternoon: 31.9 %	One shelter On total average 24.4 % Morning 23.7 % Afternoon 25.0 %
[2] Trial Four different objects: - Two-level perch - Pecking tree - Box with fir-cones - Two small fir-trees Control Five simple shelters	Different objects Morning: 39.3 % Afternoon: 39.5 %	Five simple shelters Morning: 32.4 % Afternoon: 27.1 %

[1] Rodriguez-Aurrekoetxea *et al.* (2014)
[2] Zeltner and Hirt (2008)

In addition to seeking security, enrichment on the range could also increase other behaviours. When Zeltner and Hirt (2008) enriched the range with more complex structures described in the previous paragraph, behaviours such as resting, pecking, scratching, moving and standing were increased. Most of the hens chose to stay close to structures that provided shelter and shaded areas, which shows that seeking protection is most important, compared to other behaviours (Zeltner and Hirt, 2008). When Rault *et al.* (2013) enriched the range with vertical panels the hens were seen pecking at the structures about 40 % of the total time. Moving and lying were on the other hand reduced and preening was seen more frequently in the control area.

Cornetto and Estevez (2001) saw increased resting and dust bathing behaviours when broilers were offered vertical cover panels. The total amount of preening and standing did not differ between treatments, but there was a higher frequency for these behaviours in the centre of the range when the birds were offered cover panels in that part of the area. Lubac and Mirabito (2001) saw that chickens preferred the behaviour standing in open areas with no cover and lying down in areas with cover. The authors also stated that lying down was a preferred behaviour by the chickens and ranges enriched with structures providing shade therefore were more attractive. Borland *et al.* (2010) saw a significantly higher frequency of foraging and running among laying hens when the range was enriched with shelterbelts.

2.1.4 Observation methods with an enriched outdoor run

There are different ways to measure the use of the outdoor run (Table 5). In several studies the range was divided in zones marked on the fence or with sticks in the ground, to facilitate the counting of the birds (Mirabito *et al.*, 2001; Zeltner and Hirt, 2003; Hegelund *et al.*, 2005; Borland *et al.*, 2010; Dekker *et al.*, 2012; Rault *et al.*, 2013). The number of days the observations were performed ranged between one day and 41 days for each flock (Bubier and Bradshaw, 1998; Mirabito *et al.*, 2001; Dawkins *et al.*, 2003; Zeltner and Hirt, 2003; Hegelund *et al.*, 2005; Zeltner and Hirt, 2008; Borland *et al.*, 2010; Dekker *et al.*, 2012; Nagle and Glatz, 2012; Rault *et al.*, 2013; Rodriguez-Aurrekoetxea *et al.*, 2014). The observations were in most cases executed at short intervals or on several occasions each day.

The study by Rodriguez-Aurrekoetxea *et al.* (2014) was the only one with observations on the movements of individual hens in the range while in the other trials only the total number of hens outside was determined. Some authors used video recordings or photographing (Borland *et al.*, 2010; Dekker *et al.*, 2012; Nagle and Glatz, 2012; Rault *et al.*, 2013) but the use of direct observations was the most commonly used method (Zeltner and Hirt, 2003; Hegelund *et al.*, 2005; Borland *et al.*, 2010; Dekker *et al.*, 2012; Rault *et al.*, 2013; Rodriguez-Aurrekoetxea *et al.*, 2014). The climate depends on season and country and it can have an impact on the results in a trial. It is therefore stated in Table 5 where and when the trials were executed.

Table 5. *Methods used to state the use of the enriched outdoor run among different studies.*

Zones	Number of days	Recordings each day	Recording method	Country & Season
[1] 4 zones	3 days	8 scan samples each day between 10.30 - 20.30 in first trial and 12.00 - 16.00 in second trial.	By an observer	Switzerland 1st trial: April - May 2nd trial: Aug - Sept
[2] 1) 0-10 m 2) 10-25 m 3) > 25 m	2 days/ season	Unstated	By an observer Photographs were taken when it was too difficult to count the hens.	The Netherlands All seasons
[3] No zones	6 days	1 h in the morning and 1 h in the afternoon	Video recordings	South Australia Winter
[4] 3 zones	6-41 days	15 min after opening and lasted until 17.00. 90 % recordings between 08.42 and 15.35.	By an observer	Denmark All seasons
[5]1) < 10 m 2) > 10 m	5 times/week. 8 weeks	Unstated	Observer + weakly video recordings.	Australia May - July
[6] No zones	6 weeks	6 observations during one day/ week between 10.00 - 17.00.	(Broiler) 40 birds with individual plastic ID tags. Registering the coordinates for each tagged bird.	Northern Spain March - September
[7] 3 zones: (5 m x 5 m)	5 days	Scan sampling at 30-min intervals between 12.00 - 21.00.	Video cameras. Counting birds up to 10 individuals and increments of 10 above that.	Australia Summer
[8] No zones	One time	Between opening (08.00-09.00) and closing (18.00-20.00)	(Broiler) An observer counted and photographed the birds	United Kingdom All seasons
[9]1) 0 - 21 m 2) 21 - 42 m 3) 42 - 64.5 m	8-11 weeks	3 times a day (morning, noon and evening), twice a week	Observer counted: - Percentage of hens outside - Average distance - Percentage of surface visited	France March-June
[10] No zones	2 days	Every hour during 05.00 - 20.00	By an observer	United Kingdom May-June
[11] No zones	3 days	20 min intervals Morning: 9 scans, afternoon: 9 scans --> totally 18 scans per day	Observer	Switzerland Season not stated

[1] Zeltner and Hirt (2003); [2] Dekker *et al.* (2012); [3] Nagle and Glatz (2012); [4] Hegelund *et al.* (2005); [5] Borland *et al.* (2010); [6] Rodriguez-Aurrekoetxea *et al.* (2014); [7] Rault *et al.* (2013); [8] Dawkins *et al.* (2003); [9] Mirabito *et al.* (2001); [10] Bubier and Bradshaw (1998); [11] Zeltner and Hirt (2008)

2.2 Flock size

In the European Commission's organic legislation the laying hen flock size should not exceed 3000 hens (Jordbruksverket, 2014c). It has been shown in several studies that flock size have an impact on the use of the outdoor run and the frequency increases with smaller flock sizes (Bestman and Wagenaar, 2003; Hegelund *et al.*, 2005; Gebhardt-Henrich *et al*., 2014). Hirt *et al.* (2000) saw a decrease from 41.2 % of hens on the range in a flock with 50 individuals to 19.5 % in a flock with 3000 hens. The authors suggested that with a larger group the available area per hen is lower with a decreased access to the range. This is supported by the fact that the majority of hens in all groups stayed in the area closest to the poultry house (Hirt *et al.*, 2000). Gilani *et al.* (2014) also saw a higher percentage of hens on the range when flock sizes were smaller when comparing flock sizes in a range of about 90-16000 birds. Flocks that exceeded 3000 individuals were from free-range systems and not from an organic production. Gebhardt-Henrich *et al*. (2014) also saw less foraging behaviour in hens in large flocks with 9000-18000 hens compared to flocks with 2000-9000 hens. These hens were also from farms with free-range systems and not from an organic production.

2.3 Impact of age

The age of the hens seems to have an impact on their use of the outdoor run but the results have led to different conclusions between studies. According to Gilani *et al.* (2014) pullets range at a higher frequency than older hens and 28 % of eight-week-old hens used the range compared with only 13 % of 16-week-old hens. This was also seen by Hegelund *et al.* (2005) where the number of hens on the range decreased with increased age. The authors were surprised by the results and had expected increased outdoor use with increased familiarity. They discussed several reasons for the unexpected results including poor plumage, decreased activity rate or that experience of predators increased the fear levels (Hegelund *et al.*, 2005).

Hocking *et al.* (2001) proposes that the fear level among hens increases with age and that this could be a reason why the use of the outdoor run decreases when the hens get older. In that trial, the authors exposed hens to novel objects, measured the fear level with tonic immobility and discovered that the fear level decreased with increase in age. The result disproved the authors' hypothesis but they suspect that the results were affected by an increase in familiarity with the test method (Hocking *et al.* 2001). Zeltner and Hirt (2003) on the other hand, did see a higher usage of the range by older hens, which they assumed was due to increased familiarity with the outdoor area. The number of hens outdoors were however low for all ages. In free-range broilers both Mirabito and Lubac (2001) and Rodriguez-Aurrekoetxea *et al.* (2014) saw an increase in the outdoor use with increased age and the birds also used a greater proportion of the range.

At what age the hens are first offered access to the outdoor run seems to affect how much they will use it during the rest of their life time. The younger the hens are when arriving to the farm the higher percentage will use the outdoor run during the rest of the production period (Grigor *et al*., 1995; Gilani *et al.*, 2014). Gilani *et al.* (2014) discovered that if hens got access to the outdoor run at eight weeks of age, an average of 28 % went outdoors during the trial period. As a comparison, only twelve percent of the hens used the range when they first got access to the outdoor run at 16 weeks of age. It is therefore important to offer an attractive outdoor area already at a young age (Bestman and Wagenaar, 2003). This is probably because the level of

fear is lower at a lower age when the hens first get access to the outdoor run (Grigor *et al*., 1995).

2.4 Climate, season and time of day

In countries with a temperate climate like Sweden, it is allowed to keep the organic hens inside during the cold season (Odelros, 2011). Some farms offer a protected transition area between the poultry house and the outdoor run, a so-called winter garden, veranda or bad weather run. Its purpose is to give the hens access to fresh air, natural day light and the possibility to dust bathe when the outdoor run is too unattractive due to bad weather conditions (Cooper et al., 2007). The winter garden is not included in the space of the outdoor run but is instead a part of the indoor area. It is also permitted to be used as temporary outdoor access when the outdoor run needs to be closed due to e.g. avian influenza (Odelros and Gustafson, 2007).

The climate also has an impact on hens' willingness to use the range and precipitation and increased wind speed are factors that decrease the percentage of hens in the range (Hegelund *et al.*, 2005; Gilani *et al.*, 2014). The temperature also has an impact, where the most favourable temperature seems to be at around 17°C with a decreasing number of hens in the outdoor run both at lower and at higher temperatures. If the outside temperature is high and there is little shade on the range, the climate inside the poultry house is more favourable (Hegelund *et al.*, 2005). Zeltner and Hirt (2003 & 2008) could however not see any difference in the number of hens on the range in different weather conditions. On overcast days the hens did however show a greater interest in different structures. The authors believe that it could be due to a lower level of fear among the hens during these weather conditions.

The ranging frequency also differs between seasons but what season seems to be most preferable differs between studies. In a study performed in Denmark Hegelund *et al.* (2005) concluded that autumn seems to be more favourable than spring, probably as an effect of the more unstable weather condition in early spring. In a trial executed in the United Kingdom Dawkins *et al.* (2003) on the other hand found that a higher number of birds were outside during spring and summer compared with winter and the hens preferred to be outside during warm cloudy days. Bright sunlight seems to decrease the number of birds in the range and mostly in those outdoor runs without presence of covers (Dawkins *et al.*, 2003). In Australia Nagle and Glatz (2012) saw that hens were more attracted to the shaded areas beneath the shelters in the outdoor run during the summer compared to during winter.

Whether the time of day has an impact, or not on range use is still uncertain. Hegelund *et al.* (2005) saw a decrease of hens on the range throughout the day with lowest number at five in the afternoon. The recordings did however stop after that time and number of hens outside in the late afternoon and evening is therefore unknown. On the contrary, Rault *et al.* (2013) and Dawkins *et al.* (2003) saw a higher number of hens in late afternoon and evening. Bubier and Bradshaw (1998) also saw that the number of hens increased with increased time of day where the highest percentage of hens were seen at 18.00 o'clock whereas the lowest number were seen two to four hours after opening of the pop-holes. The behaviour of the hens also differs with time of day and Zeltner and Hirt (2008) concluded that hens feel more insecure during the morning and therefore seek shelter to a greater extent at that time of day. In the afternoon the fear level seems to decrease and the hens become more active and spend more time to perform other behaviours.

2.5 The poultry house

The design of the poultry house together with its interior could have an impact on the animal welfare and also the hens' willingness to use the range. Shelters and other structures are as already mentioned attractive to poultry regardless if they are placed inside or outside the poultry house.

It is not allowed to feed the poultry on the range because of the increased risk of attracting vermin and by that an increased risk of infection. Instead the feed are to be provided inside the poultry house, either at set feeding times or *ad libitum*. Bubier and Bradshaw (1998) saw that feeding *ad libitum* had a favouring effect on number of hens using the outdoor run because the hens felt less need to keep close to the poultry house in anticipation of the next feeding.

According to the EU regulation on organic egg production laying hens shall be offered natural daylight and complementing artificial light during a maximum of 16 hours a day with a minimum of cohesive darkness during eight hours (Jordbruksverket, 2014c). The difference in light intensity between inside the poultry house and the range can affect the hens' willingness to go outside. Gilani *et al.* (2014) saw a higher number of hens in the outdoor run when the light inside the poultry house was more intense. When the light inside is more intense the difference in light between outside and inside is reduced and the hens therefore dare to go out. Dekker *et al.* (2012) saw that the range with the highest percentage of hens had a transparent curtain between the winter garden and the pasture causing a low difference in light intensity.

The EU regulation on organic egg production requires that the size of the pop-holes should be at least four meter per 100 m^2 of available area inside the poultry house (Jordbruksverket, 2014c). Each pop hole should be at least 35 cm high and 40 cm wide and there must be at least a two-meter opening per 1000 hens (European Union, 1999). According to the regulation of KRAV the pop-holes should also be evenly spread along the wall facing the range (KRAV, 2014c). The size and availability of the pop-holes could have an impact on the number of hens using the outdoor run. Gilani *et al. (*2014) stated that with greater length of the pop-holes the percentage of hens on the range increases because it thus decreases the distance to the closest pop-hole. This was however disproved by Harlander-Matauschek *et al.* (2006) who did not find any differences in the usage of the range with different pop-hole sizes. The authors did however highlight that the smallest pop-hole was 2.34 m/1000 hens, which is more than the minimum requirements and probably wide enough to provide the hens with ample space to go out.

2.6 Feather pecking and cannibalism

The mortality in organic egg production is higher than the conventional systems, especially compared to cage systems (Borell and Sørensen, 2004; Fossum *et al*., 2009). In a Swedish investigation it was concluded that the most common cause of mortality in free-range systems was bacteriological diseases and thereafter cannibalism (Fossum *et al*., 2009).

Feather pecking is a common problem in the organic egg production and Bestman *et al.* (2009) found that more than 50 % of the flocks with organic laying hens had a feather pecking prevalence of more than six percent of the birds during the rearing period. However, which hybrid was used in the study was not specified. This problem behaviour can be linked to animal welfare issues and is e.g. correlated to a higher mortality (Bright *et al.*, 2011). Feather pecking is a difficult problem to manage and if it occurs during the rearing period it will to a

high extent continue during the rest of the laying period (Bestman & Wagenaar, 2006; Bestman *et al.,* 2009).

Beak trimming is a method to prevent the occurrence of feather pecking but yet only a method that hides the problem, not resolve its cause. In both conventional and organic production systems in Sweden all types of mutilations including beak trimming, are prohibited (Svenska Ägg, 2014) and strictly regulated in organic production in the EU (European Union, 2007). Even so, beak trimmed hens may occur on organic egg farms in some EU countries because they are mutilated at an early age and thus before it is determined if they are to be sold to organic or conventional farms (Ministry of Agriculture, Fisheries and Food, 2000). In Canada (PWGSC, 2011) and in United States of America (GPO, 2015) it is allowed to beak trim organic laying hens if necessary to prevent behavioural problems.

Poor plumage caused by feather pecking decreases the hen's ability to maintain her body temperature and she is more vulnerable to wind and rain. It is therefore possible to believe that she would be less willing to go outside if her plumage condition is poor but few studies have investigated this hypothesis. Several authors have on the other hand, stated that the level of feather pecking decreases with access to an outdoor run (Bestman & Wagenaar, 2003; Shimmura *et al.,* 2008). The reason is not clear but could be due to an increase in stimulation together with a lower density inside the poultry house. Some authors have declared that even if the hens have access to a range, the feather pecking behaviour increases when the use of the outdoor run is low (Pötzsch *et al.,* 2001; Nicol *et al*., 2003; Shimmura *et al.,* 2008). Bright *et al.* (2011) saw decreased plumage damage when hens had access to canopy shelters in the outdoor run and Mahboub *et al.* (2004) saw as a consequence of low outdoor usage that the white hybrid had a higher level of plumage damage.

Even if several studies indicate that feather pecking decreases with outdoor use it is not always the case (Gilani *et al.,* 2014). Nagle & Glatz (2012) could not see any difference in feather pecking or plumage condition between hens with or without access to shelters or forage in the outdoor run. The overall feather pecking was however very low and could be due to the small flock sizes during the trial.

2.7 Hybrids

The laying hens used in the commercial egg industry derive from a few large international breeding companies and have been highly selected for increased production. Consequently exploratory and foraging behaviours has decreased as well as fear for predators which is lower in the domestic hybrid compared to the ancestor Red jungle fowl (Schütz *et al*., 2001).

There are differences in use of hybrids between countries and in e.g. Sweden (SLU, 2010) and Switzerland (Gebhardt-Henrich *et al.,* 2014) white hybrids are most commonly used while brown hybrids are dominating in most European countries (SLU, 2010). Behavioural differences have been found between the commercial strains used in the egg production and especially between white and brown hybrids. White hybrids seem to have a better ability to adapt to new environments due to their lively temperament and therefore have a lower mortality in loose housing systems compared to brown hybrids (Tauson *et al*., 1999).

Which hybrid to use can be important in organic egg production because of the difference in use of the outdoor run. Gebhardt-Henrich *et al.* (2014) found a higher percentage of hens

outdoor in flocks with brown hybrids compared with white hybrids. Mahboub *et al.* (2004) also saw a smaller usage of the range by the white Lohmann Selected Leghorn (LSL) compared to brown Lohmann Traditional, a result due to the white LSL being a more anxious hybrid. Even if the meat production differs in several aspects from the egg production Dal Bosco et al. (2010) saw great differences in number of chickens outdoors and also distance moved when comparing a slow growing with a fast growing broiler genotype. This indicates that when breeding for high production traits it could lead to a decrease in other behaviours, such as exploration and foraging. The reduced activity in the fast growing broiler could according to the authors also be due to the higher prevalence of foot damages in that genotype.

Elwinger *et al.* (2008) saw a higher usage of the range with the experimental genotype SH (Swedish Hen, SLU-1329) that is a cross between the experimental strains Rhode Island Red and White Leghorn, compared to the Lohmann Selected Leghorn. In another trial by the same authors the percentage of hens outdoors was higher with Hyline compared to SH. Both Hyline and SH had better plumage condition than LSL. This suggests that some hybrids might be more adapted to organic conditions than others (Elwinger *et al.*, 2008).

2.7.1 Feather pecking among different hybrids

The genetic selection for the commercial laying hybrids has been focused on cage systems. Sørensen (2001) addressed in 2001 that with an increased number of loose housing and range systems, other traits such as increased nesting behaviour, decreased feather pecking and cannibalism needed to be included in future breeding programs. A decreased live weight is also included in the breeding program for laying hens and Kjaer and Sørensen (1997) believe that there is a correlation between the lower body weight within hybrids and increased feather pecking. The authors consider that feather pecking is best reduced by selection on well-feathered individuals as has been done in Denmark with good results.

Brown hybrids show high production and good health in cage systems but with the increasing number of loose housing systems this hybrid meets several problems such as feather pecking. In conventional production this behaviour is prevented through beak trimming but exists in organic production where this mutilation is prohibited. Tauson *et al.* (1999) saw a much higher feed intake, worse plumage condition and higher mortality in Lohmann Brown (LB) kept in a loose housing system compared to cage systems. In contrast, the white LSL showed no difference in performance or health between the different systems. Tauson *et al.* (1999) also compared mortality between the hybrids in a loose housing system and found a much higher incidence in the brown hybrid as well as a higher feed consumption ratio due to poor plumage condition. Elwinger and Tauson (1999) would recommend using white hybrids in loose housing systems because of the lower risk of feather pecking when beak trimming is not allowed.

Kjaer & Sørensen (2002) also saw a higher frequency of feather pecking, poor plumage condition and skin damage in the brown hybrid ISA Brown and comb damage in New Hampshire whilst the white hybrid White Leghorn had no plumage damage at all. The mortality was highest in ISA Brown and mostly caused by cannibalism. In another trial by the same authors ISA Brown had the lowest incidence of feather pecking compared to the Danish Landrace and LSL, where the Danish Landrace was absolutely worst (Kjaer & Sørensen, 2002). Kjaer and Sørensen (1997) saw five times higher frequency of feather pecking in the brown hybrids LB and ISA compared to the white hybrid LSL at 38 weeks of age. There are

also differences in behaviour between white hybrids and Elwinger and Tauson (1999) saw a higher feed consumption due to a worse plumage condition in DeKalb compared to LSL. As a consequence the mortality was also higher with the higher incidence of feather pecking.

3 Material and methods

The practical part of the master thesis was conducted on four commercial farms with the purpose to compare if different placings of shelters in the outdoor run can attract more hens to use and move further out on the range. Two different arrangements were compared, with enrichment placed in a line in one set and in a zigzag formation in the other. The hens had access to both arrangements during the whole trial period and the two arrangements consisted of the same number and same type of structures. The number of hens in the trial zone was counted as well as the distribution of the hens with regard to the distance from the poultry house and within the area of each set of enrichment.

3.1 Design and placement of the enrichment

Each arrangement of enrichment consisted of eight artificial roofs with four wooden legs and a tin roof (Figure 1) and eight big straw bales. With two different placements the total amount of enrichment in each range was thereby 16 roofs and 16 straw bales. The first set of enrichment was placed in a line with a straw bale and thereafter a roof and so on (Figure 2 & 3). In the second arrangement pairs with one roof together with a straw bale was placed in a zigzag formation with ten meters in diagonal from each other (Figure 3 & 4).

Figure 1. *A shelter with a tin roof and four wooden legs*

Figure 2. *Enrichment placed in a line with shelters and straw bales one after another*

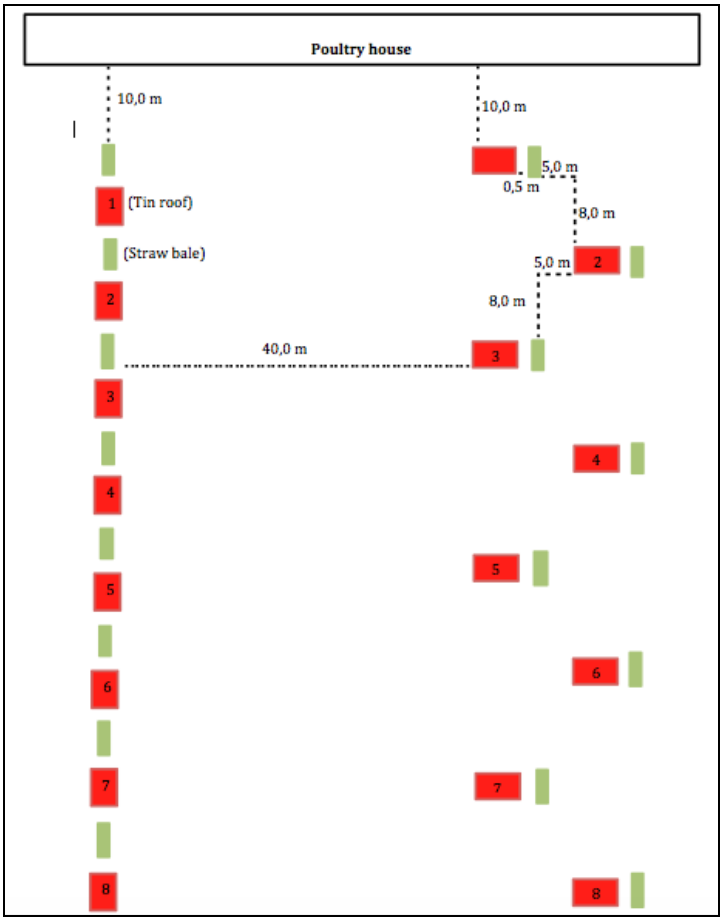

Figure 3. *Drawing of the arrangements of the enrichment on each farm.*

Figure 4*. Placement of shelter and straw bale in the zigzag arrangement*

The trial was an on-farm study conducted on four different organic egg farms in the region of Östergötland in Sweden between April and May in 2015. All farms had between 12000-18000 hens of one of the white hybrids, LSL or Bovans that were between 25 and 47 weeks old (Table 6). The hens of all four farms had not had access to a range before the actual season. They had been let out between 19-40 days before the trial and the enrichments were placed on the range between 8-40 days before the first observation. All farms used so-called shared grass ley pasture with other species and with pop-hole openings on both sides of the poultry house, although the trial's enrichment was only arranged on one side of the house. The length of time

for access to the outdoor run was approximately twelve hours a day and the pop-holes were opened at 08.00 or 09.00 in the morning and closing at 21.00 in the evening. Both the line and the zigzag arrangement reached out between 80-85 meters from the poultry house out in the range.

Table 6. *Details of the housing system and routines on each farm in the trial*

Farm	**1**	**2**	**3**	**4**
No. of hens	12000	18000	18000	18000
Roosters (no.)	Yes (unstated)	Yes (63)	Yes (85)	Yes (unstated)
Hybrid	Bovans	LSL	LSL	Bovans
Other species in range	Yes, sheep	Yes, horses*	Yes, sheep*	Yes, sheep*
No of feeding times	Five times/day	Five times/day	Six times/day	Six times/day
Age at trial	30 weeks	25 weeks	27 weeks	47 weeks
First access to range	10 April	2 April	5 April	1 April
First access to the trial's enrichment	20 April	7 April	13 April	1 April
Opening time	09.00	08.00	09.00	09.00
Closing time	21.00	21.00	21.00	21.00
Time of light	16 h	15.5 h	16 h	16 h
Indoor system	Aviary system	Aviary system	Aviary system	Aviary system
Winter garden	Yes	Yes	Yes	Yes

*The other species in Farm 2, 3 and 4 where not present during the trial but where to be inserted in the outdoor run later during the summer.

To decrease the risk of bias due to environmental differences, the placing of the enrichment varied between the farms. On two farms the zigzag formation was placed on the left side of the poultry house and the line formation on the right side. On the other two farms it was arranged in the opposite way. To minimise the risk of placing the first enrichment too far away from the poultry house it was positioned five meters out on Farm 3 and 4 and ten meters out on the other two farms.

3.2 Collection of data

Since the hens on all four farms had access to the outdoor run on both sides of the poultry house it was not possible to count the total number of hens outside at each visit. The trial area of the range was divided into 15 zones to simplify the counting of hens and to measure the distance between the hens and the poultry house. The trial area was divided into five distances from the poultry house: 0-20 m, 20-35 m, 35-50 m, 50-65 m and 65-85 m. Each distance was divided into three parts of the same size: one surrounding the line formation, the zigzag formation and the last one including the empty control area. The zones were not marked and the observer used the enrichment as help to divide the area into zones. For example, on the farms where the enrichment started ten meters from the poultry house the first distance

included a straw bale and a roof in the line arrangement and one straw bale and roof in the zigzag arrangement, and so on.

Each farm was visited seven times and observations were made during one hour at every visit. Two farms were visited each observation day, one during the morning right after time of pop-hole opening and the other in the afternoon sometime between 15.00 and 18.00 o'clock. Time for the afternoon visit was decided each day with help of the weather report and observations during heavy rain or very strong wind were avoided if possible. Every farm had three to four visits during opening time and three to four visits during the afternoon. On each visit the observer counted the number of hens in each zone at intervals of ten minutes with a total of six observations for each farm and day. The weather was registered at each visit and categorized as: 1 = Sun and blue sky, 2 = Sun and clouds, 3 = Overcast and 4 = Rain. The temperature was also stated as well as the wind: 1 = Calm, 2 = Moderate, 3 = Strong and 4 = Very strong. The observer estimated weather visually and wind by sense while the thermometer in the car registered the temperature.

On one occasion on each farm the observer went inside the poultry house to score the plumage condition and measure light intensity. To score the plumage condition the observer walked through the poultry house and looked at 100 hens. The hens were chosen randomly by shifting the gaze between hens on the floor, in the nest and at feeders on all the levels in the aviary. The plumage condition of each hen was visually and roughly estimated and given a score between 1-5 with guidance by LaBrash and Scheideler (2005): 1 = Fully feathered, 2 = Tousled but no naked areas, 3 = < 5 cm naked areas, 4 = > 5 cm naked areas and 5 = Naked areas with wounds or/and blood. The light intensity was measured in lux using a digital luxmeter (Mastech® MS6610 Luxmeter) at five different places: at feed tray, at pop-hole inside the poultry house, veranda, inside the veranda at pop-hole facing the outdoor run and outdoors.

3.3 Statistical analyses

The number of hens in the different areas, control, zigzag and line were compared, both for the total trial area and at different distances from the poultry house. The values used were the average number of hens for each farm. Since the data was not normally distributed the non-parametric Wilcoxon signed rank test was used. To investigate the impact of the climate and time of day, correlation analyses were performed. All analyses were carried out with the statistical program Excel (Microsoft® Excel® for Mac 2011 Version 14.5.2).

4 Results

The mean percentage of hens outdoors on the side of the poultry house where the trial was executed, ranged between 0.16 - 1.77 % of the total population on each farm, with the lowest percentage on Farm 4 and the highest on Farm 3. The number of hens in the total trial area ranged from 2-386 individuals depending on day and farm. The number of hens varied between 94-267 on Farm 1, 2-386 on Farm 2, 245-381 on Farm 3 and 16-56 on Farm 4.

4.1 Distribution of hens in the entire trial area

In Figure 5, a comparison between number of hens in the total area with enrichment and in the control area is demonstrated. It is shown that the areas with enrichment seem to be more

attractive to the hens on at least three of four farms with a more apparent result in Farm 3. The number of hens in Farm 4 shows no difference in number of hens between enriched areas and the control area, but the farm had a very low number of hens outside.

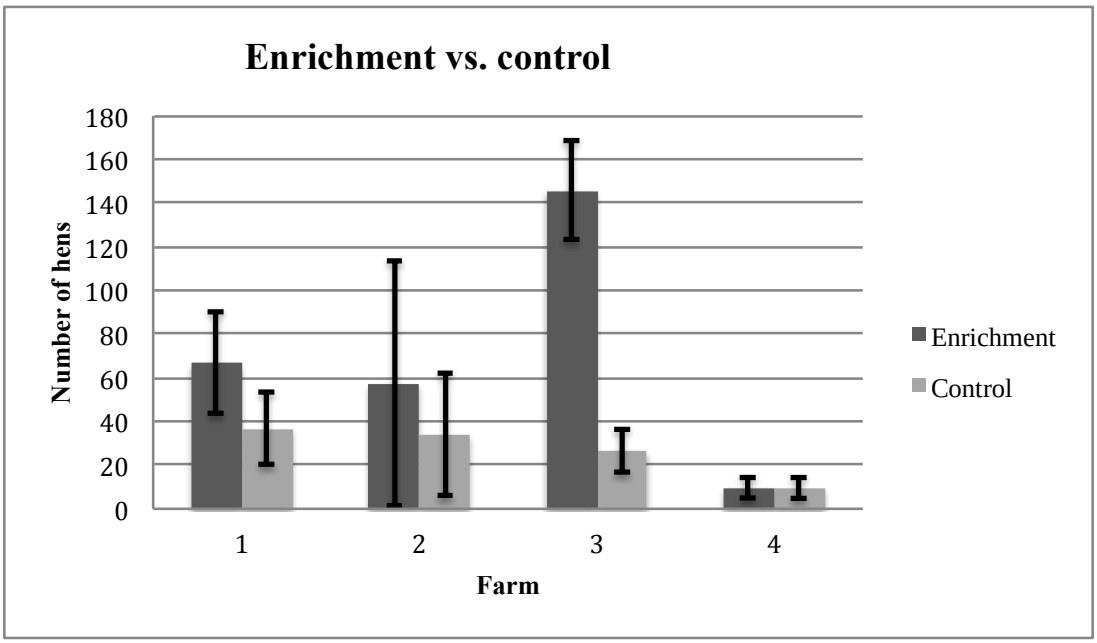

Figure 5*. Number of hens (mean± st dev) in the control and enriched areas on each farm. Since the total enriched area is twice as large as the control, the dark grey columns represent the mean value of the two enriched areas and the light greys the control.*

The average distribution of hens for all four farms together shows no clear difference between the area with enrichment arranged as a line and as a zigzag formation (Figure 6). The difference varies between farms with a higher number of hens within the zigzag area on Farm 1 and 3 while the line formation seem to be more attractive on Farm 2. The distribution of hens on Farm 4 shows no difference between treatments but the total number of hens outside was overall very low.

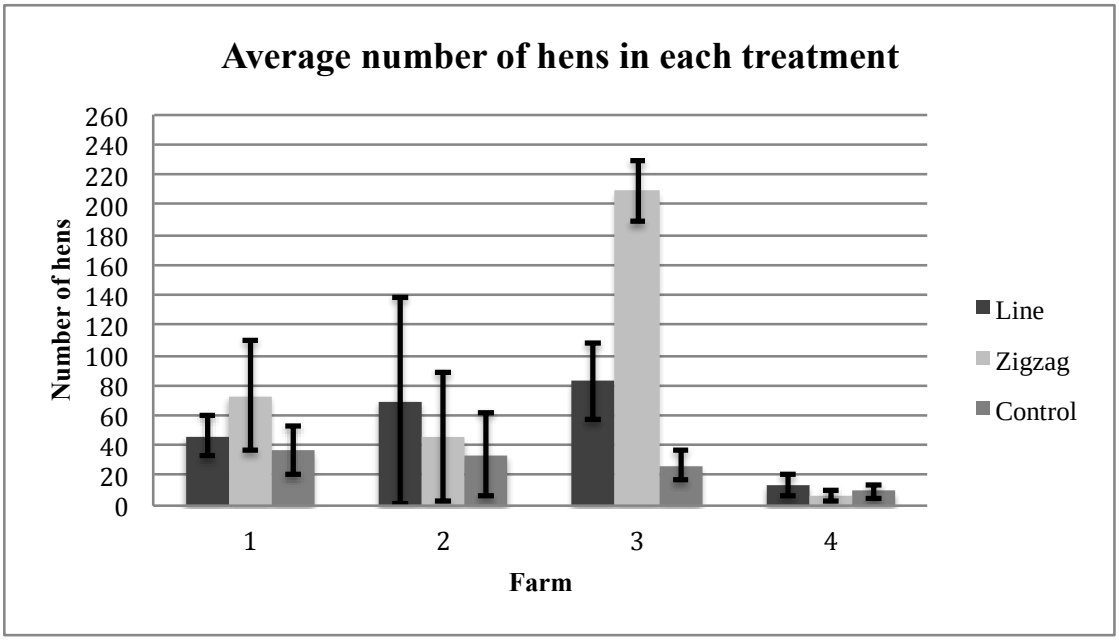

Figure 6. *Number of hens (mean± st dev) in the three treatment areas in the four farms.*

The average number of hens for all farms together for each treatment was 53.0 ± 46.9 (mean ± stdev.), 83.5 ± 79.8 and 26.7 ± 19.3 within the Line, Zigzag and Control area respectively.

There was a tendency that there were more birds in the enriched areas compared with the control area (P=0.068) (Table 7). There were no significant difference between the areas with the line formation and the zigzag formation (P=0.465).

Table 7. *Non-parametric statistic analysis with Wilcoxon signed rank test of distribution of hens in the total trial area, all four farms together. N=4 represents mean values from each farm. Since the total enriched area is twice as large as the control area the values used for the enriched areas are mean values.*

	N	**Mean**	**Range**	**P-value**
Enrichment	4	70.06	9.94 - 146.01	0.068
Control	4	26.75	9.60 - 36.74	
Line	4	53.05	13.76 - 82.43	0.465
Zigzag	4	87.07	6.12 - 209.59	

4.2 Distribution of hens in different distances from the poultry house

During the experiment the trial area was divided into different zones to estimate the number of hens at different distances from the poultry house. The first zone included a distance of 0-20 m, the second 20-35 m, the third 35-50 m, the fourth 50-65 and the fifth 65-85 m. The results from the two latter distances were excluded because no or only a few hens were observed so far out. The average number of hens within the distance of 0-20 m varied greatly with observation day and farm, between 2-251 birds. At Farm 1-3 there was a higher number of hens in the enriched areas compared to the control area without enrichment. The fourth farm showed no difference but the number of hens outside was overall very low. In Table 8 it is shown that there was a difference in average number of hens in the enriched areas compared to the control area but the difference was not statistically significant (P=0.144). Since the total enriched area was twice as large as the control area, the average number of hens within the enriched area was divided by two. The difference in number of hens between the line and the zigzag formation was not clear but the zigzag formation seemed to be slightly more attractive on Farm 1 and 3 but not on Farm 2 where the result was rather the opposite. The difference in number of hens between the different placing of the enrichment within this distance was not statistically significant (P=0.465) (Table 8).

Within the distance of 20-35 m from the poultry house the number of hens was lower, between 0-88 hens depending on day and farm, compared to 0-20 m but the distribution was similar. Number of hens in the enriched areas was higher than in the control area on Farm 1-3 but no difference was seen in the fourth farm. The difference between the areas was not statistically significant with a P-value of 0.068. The number of hens on the latter farm was overall low, less then five hens in each treatment area. There was a marginally higher number of hens in the area with the zigzag formation than the line on Farm 1 and 3 but not on Farm 2. The difference was not statistically significant with a P-value of 0.465, which is shown in Table 8.

The number of hens within the distance of 35-50 m from the poultry house was overall very low on the four farms and especially on Farm 1, 2 and 4 with fewer than five hens in each treatment area. Only Farm 3 could encourage a higher number of hens to visit that area but the

amount varied between 21-56 individuals for each observation day. The difference between the enriched areas and the control was not statistically significant with a P-value of 0.068 (Table 8). The difference between number of hens in the zigzag area and the line was clear on Farm 3 with an evidently higher amount within the zigzag area. This could not be seen in any of the other three farms and there was no statistically significant difference between the two types of placements (P=0.465) (Table 8).

Table 8. *Non-parametric statistic analysis with Wilcoxon signed rank test of the distribution of hens at different distances from the poultry house, all four farms together*

Distance	Comparison	N	Mean	Range	P-value
0-20 m	Enrichment	4	52.46	8.94 - 92.07	0.144
	Control	4	25.32	9.6 - 36.31	
	Line	4	43.55	12.38 - 61.57	0.465
	Zigzag	4	61.37	5.50 - 129.26	
20-35 m	Enrichment	4	12.46	8.47 - 33.35	0.068
	Control	4	1.37	0.00 - 4.26	
	Line	4	8.21	0.74 - 21.64	0.465
	Zigzag	4	17.00	0.64 - 45.05	
35-50 m	Enrichment	4	4.98	0.12 - 19.36	0.068
	Control	4	0.07	0.00 - 0.29	
	Line	4	1.07	0.10 - 3.60	0.465
	Zigzag	4	8.89	0.00 - 35.12	

4.3 Plumage condition and light intensity

To take into account possible differences between the four farms the observer recorded the average plumage condition on one occasion on each farm and the results are shown in Table 9. On Farm 1-3 the hens were perfectly feathered with no visible sign of feather pecking. Farm 4 stood out with a poor plumage condition on almost all hens and approximately 80 % had visible naked areas and half of the population had naked areas larger than five cm (Table 9).

Table 9. *Measured percentage of hens in each plumage score for every farm*

	Plumage condition score*				
	1	2	3	4	5
Farm					
1	96	4	0	0	0
2	93	7	0	0	0
3	100	0	0	0	0
4	8	13	29	50	0

*1 = Fully feathered
2 = Tousled but no naked areas
3 = < 5 cm naked areas
4 = > 5 cm naked areas
5 = Naked areas with wounds or/and blood

At the same time as the plumage condition was evaluated, the light intensity in the poultry house was also measured. The purpose was to determine the difference between the four farms in light intensity between the indoor and outdoor environment and the increase in light between the different pop-hole entrances. The results are shown in Table 10 and the light intensity differed greatly between the feed tray (1-11 lux) and outdoors (>50000 lux) on all four farms. The light intensity inside the poultry house at the pop-hole opening to the winter garden differed between 86-915 lux with the lowest value at Farm 4 and the highest at Farm 3. The same pattern was seen in the middle of the winter garden where the values varied between 160-1569 with the lowest lux once again on Farm 4 and the highest on Farm 3. The last value of light intensity was measured inside the winter garden at the pop-hole entrance to the outdoor run and the results differed between 1915 to 9740 with the lowest value at Farm 1 and the highest again on Farm 3.

Table 10. *Measured LUX-level at different places in the poultry house on each of the four farms*

Farm	At feed tray	Pop-hole inside	Winter garden	Pop-hole winter garden
1	1	312	320	1915
2	11	428	1019	5876
3	1	915	1569	9740
4	1	86	160	4607

4.4 Climate and time of day

At each observation visit both the temperature, weather, time of day and wind strength were registered to evaluate their effect on the hens' outdoor use. In Table 11 the frequency for each climate condition is shown together with the mean number of hens outdoors within the trial area.

There were small differences between the weathers sun, sun and cloud and overcast in the number of hens in the trial area and the large standard deviations show a great variation for each weather condition. Heavy rain only appeared at one observation visit at Farm 2 resulting in an average of two hens outdoors in the trial area. The r-value is low and no correlation between weather and number of hens outdoors can be stated. The r-value for wind is also low and there was little difference between the strength in wind on the number of hens outdoors in the trial area. The standard deviation for calm wind is quite low because the number of hens was over 150 hens every time the wind was calm. The number of observations during calm wind was however only three and it is therefor difficult to draw any conclusions.

Number of observations performed at mornings and in the afternoon is almost the same although with a slightly higher number of observations made in the afternoon (Table 11). There was no difference in number of hens between time of day and the standard deviation is large and shows great variation in number of hens for each day. With only two different parameters no correlation could be estimated. The result for the different temperatures is difficult to evaluate with only one observation during four, five, seven, eleven and 18 °C and none below four, above 18 or at six degrees Celsius (Table 11). Observations during twelve degrees were most common during the present trial but the variation in number of hens outdoors in the trial area was great.

Table 11. *Observation of weather, wind, time of day and temperature stated once at each observation visit for all farms together and its correlation with the number of birds outside (mean±SD).*

	r-value		N	Mean	St.dev
Weather	-0.06	**Sun**	4	100.6	148.9
		Sun and clouds	11	170.6	140.4
		Overcast	12	199.8	107.2
		Rain	1	2.17	-
Wind	-0.23	**Calm**	3	199.8	38.6
		Moderate	11	200.6	128.6
		Strong	9	134.7	129.9
		Storm	5	132.1	168.3
Time of day		**Am**	12	177.8	129.3
		Pm	16	159.1	132.0
Temperature	0.14	**4**	1	2.2	-
		5	1	214.3	-
		7	1	170.8	-
		8	2	169.8	22.5
		9	2	273.8	158.2
		10	7	144.6	156.2
		11	1	94.2	-
		12	8	164.8	146.1
		14	4	175.7	132.7
		18	1	277.5	-

5 Discussion

The legislation and requirements for organic production are continually shifting and farmers need to be adaptable to maintain their organic labeling. The latest change faced by the organic egg producers in Sweden that are certified according to the rules of the Swedish organization KRAV, is a new direction in the design of the range and the obligation to ensure that the hens utilize the total given outdoor area. In this master thesis the purpose was to investigate if the placings of enrichment could have an impact on the distribution of the hens in the range. The result could not show any significant differences between the two different arrangements but there were indications that enrichment, regardless of its position does have a stronger attractiveness than areas without enrichment and that it motivates the hens to move further out in the paddock.

5.1 Distribution of hens in the outdoor run

The trial was conducted on four different farms chosen to be as similar as possible, although there were several differences between them. The number of hens outdoors could only be counted for within the trial area even though all the poultry houses had openings on both sides of the building. For all four farms the number of hens at each observation was very low and hens within the experiment area were on average less than two percent of the total population. At each visit day the observer viewed the other side of the poultry house to get an indication of if the number of hens differed greatly on the two sides of the poultry house. Without counting the hens the observer could not see any clear difference in number of hens outdoors between either sides of the poultry house.

There was a tendency that birds preferred to be closer to the enrichments and in figure 5-6 it is clearly shown that there were more hens in the enriched areas compared to the control area on three of four farms. That hens prefer to stay in areas with enrichment has been confirmed in several studies (Mirabito *et al.,* 2001; Dawkins *et al.,* 2003; Hegelund *et al.,* 2005; Borland *et al.,* 2010; Dekker *et al.,* 2012; Nagle and Glatz, 2012; Rault *et al.,* 2013). The results from Farm 4 in the present study did however not confirm this, which is similar to the results by Zeltner and Hirt (2003). The number of hens outdoors on the fourth farm was on the other hand very low and it is therefore difficult to draw any strong conclusions by that result.

In the present trial the same enrichment, tin roofs and straw bales, were placed in two different ways: one as a line and the other as a zigzag formation. In this experiment the result in number of hens between the two different placements was irregular and varied between farms. On Farm 1 and 3 the hens seemed to prefer the area with the zigzag arrangement while the hens on Farm 2 were more attracted to the line formation. Over all there was no obvious difference in number of hens between the two arrangements and the difference was not statistically significant (Figure 6; Table 7). This is the first trial where two different arrangements of equal enrichments have been compared as in earlier studies the majority have compared the difference with or without enrichment (Mirabito *et al.,* 2001; Dawkins *et al.,* 2003*;* Borland *et al.,* 2010; Dekker *et al.,* 2012; Nagle and Glatz, 2012; Rault *et al.,* 2013; Rodriguez-Aurrekoetxea *et al.,* 2014).

As a result of the new regulation by KRAV where the farmers with an organic egg production are obligated to ensure that the hens use the whole given surface in the paddock (KRAV, 2013), the main purpose of the present study was to increase the distribution of hens in the range and encourage the hens to move further out. In all four farms it was clear that the hens moved further out on the range in zones with enrichment compared to the control area. This was also seen in studies by Dawkins *et al.* (2003), Borland *et al.* (2010) and Rault *et al.* (2013). The difference in the present study was however not statistically significant (Table 8).

The distance the hens moved away from the poultry house did not differ significantly between the two arrangements (Table 8) and again the results differed between farms. The hens moved as far out as 35-50 m and only 20-35 m in the control area. It needs however to be pointed out that it was only on Farm 3 a larger group of hens was seen within the area of 35-50 m. On the latter farm the majority of the hens at that distance stayed within the area with the zigzag arrangement. On Farm 1 and 2 only a few hens ever went as far out as 35-50 m and on Farm 4 none was seen in that area.

5.2 External factors that may have affected the outcome

As previously mentioned, the hens on Farm 1 and 3 preferred the area with enrichment arranged in a zigzag formation. On both of these farms that arrangement was placed on the right side of the poultry house close to the concrete wall of the manure container. It is possible that it was not only the arrangement of the enrichment that attracted the hens but also the concrete wall giving a sense of security and thus increased the number of hens in that area. On Farm 2 the zigzag formation was placed on the side of the poultry house closest to the road where cars and machines enters the farm. This could be experienced as a more fearful area of the range and therefore contribute to the lower number of hens in that area.

On Farm 2 and 3 heavy rain fell during the period of the observations creating puddles that seemed to be attractive to the birds. On Farm 2 the puddles appeared where the enrichment

was placed in a line and on Farm 3 in the area of the zigzag formation. These areas attracted more hens and the reason for this could consequently be due to the appearance of puddles. On Farm 1, two straw bales had accidently broken down within the area of the zigzag formation creating two piles of straw. The hens seemed to be attracted to these piles and this could therefore be a reason to the higher number of hens in that area.

Poultry are prey animals with enemies in both the sky and on the ground. They are anxious animals that seek shelter as soon as there is a risk of danger. This was observed during the trial when even the smallest bird in the sky caused the hens to run inside.

5.3 Trial design and collection of data

As described earlier there have been very few studies comparing the attractiveness of the outdoor run with placing of enrichment and arrangement of the same type of artificial enrichment has never been examined before. To place enrichment in a line (Nagle and Glatz, 2012; Rault *et al.* 2013) or spread it such as in a zigzag formation (Zeltner and Hirt, 2008) has been done earlier, but never together in the same trial with the same components. The lack of previous research was the reason why that method was chosen in this master thesis but also with the belief that the placement of shelters has an importance. How arranging the enrichment could effect the distribution of the hens in the range has not been investigated earlier. Even if no difference could be found in this master thesis, the hypothesis that arrangement has an importance cannot yet be rejected after only one trial.

It is also more common to perform trials about outdoor use on artificial, scientifically adjusted ranges instead of on commercial farms. There is obviously an advantage with the first type of experiment with a reduction in different factors when the outdoor runs are the same in design, hens are the same breed, age and from the same hatchery, to name a few. On the other hand there is a great risk that the results obtained in a scientifically designed farm are not applicable to a commercial farm because the environment and conditions are too different from each other. If organic farmers are to benefit from the results from scientific experiments, the trials should be adapted to the target group. Ranges designed for scientific purposes are often smaller and in other ways different from ranges on commercial farms. Since the idea of this master thesis arose from the previously described rule change by KRAV, it was urgent to get results as soon as possible and the trial of this master thesis was therefore carried out on commercial farms.

The collection of data by counting at short intervals was inspired by earlier studies (Table 5) (Zeltner and Hirt, 2008; Rault *et al.*, 2013) but the intervals in the present study were slightly shorter. This was due to the low variation in the number of hens outside over a few hours, decreasing the necessity to observe during a longer period at each observation. Instead there was a great minute to minute variation with hens running back and forth to the poultry house due to frightening birds in the sky or similar events. To count only once an hour had probably increased the risk of counting when the hens had just moved inside giving a weak result when the hens just seconds after returned out again. In the present trial an interval of ten minutes was chosen to decrease that risk.

Both financial assets and time limited the number of days the observations were conducted. Each farm was visited seven times, which is similar to several other studies (Table 5), but it would have been of interest to continue observations at the end of the season to see if

familiarity with the enrichment could increase both the number of hens outdoors and the difference between the two arrangements of the enrichments.

The most common method to count number of hens outdoors in other studies has been direct observations (Table 5) (Bubier and Bradshaw, 1998; Mirabito *et al.,* 2001; Zeltner and Hirt, 2003; Hegelund *et al.,* 2005; Zeltner and Hirt, 2008; Rodriguez-Aurrekoetxea *et al.,* 2014). Video recordings might have decreased the risk of miscounting but it was not possible to include video cameras in the trial for both financial and time restrictions. When number of hens within one zone exceeded 100 individuals the observer counted by estimating hens in groups of ten birds. The risk that the outcome would have been different or more accurate by using video recording is rather low.

5.4 Climate, season and time of day

At each observation visit the outdoor temperature was measured and weather and wind was assessed. The result is shown in Table 11 but with an unequal number of observations for each climate parameter it is difficult to make a conclusion of if weather, wind and temperature have an impact on hens' willingness to go outdoors or not. Instead, their impact on the result is to be discussed as follow. Heavy rain and strong wind effectively decreased the number of hens outdoors. This is for example seen in the present study on the third observation day on Farm 2 when there was a heavy rainfall and the average number of hens outdoors within the trial area was less than two birds. This is also confirmed by Hegelund *et al.* (2005) and Gilani *et al.* (2014).

The region where the study was conducted, Östergötlands län, is an area with large areas of open plains and is therefore often quite windy. During the observations the wind was only scored as calm on three observations. The most common score was moderate followed by strong and then very strong. Strong wind has been seen to decrease the number of hens outside in earlier studies (Hegelund *et al.,* 2005; Gilani *et al.,* 2014). Dawkins *et al.* (2003) saw that the hens preferred to be outside during warm cloudy days while bright sunlight on the other hand seemed to decrease the number of birds in the range. During the present study no clear difference in outdoor use could be seen between sunny days, overcast or light rainfall which confirms the results Zeltner and Hirt (2003) and Zeltner and Hirt (2008). They did on the other hand discover a different pattern of behaviour dependent on weather, but in the actual study different behaviours were not registered and therefore could not be analysed.

The temperature varied between four and 18°C but with few observations no correlation could be drawn between temperature and number of hens outdoors. According to Hegelund *et al.* (2005) the most favourable temperature is at 17°C and the number of hens decreases both with increasing and decreasing temperatures.

During the present trial the impact of time of day is shown in Table 11 but there was no clear difference between number of hens outdoors between morning and afternoon. Two farms were visited each observation day, one at opening time and the other in the afternoon. The purpose with the study was to evaluate the placing of enrichment and it was therefore of importance to chose the time of day when most hens were likely to be outside. The best time for observations was, after deliberation with the farmers, assumed to be at opening of the pop-holes and afternoon at 15.00-17.00 o'clock. At midday and evening the farmers experienced the lowest number of hens to be outdoors. On one occasion one observation was conducted at sunset on Farm 2 and the number of hens outside was lower than at other times. A similar pattern was

found by Hegelund *et al.* (2005) who saw a decrease in number of hens outdoors with increasing time of day. In that study the recordings did however stop after 17.00 and number of hens outside in the late afternoon and evening is therefore unknown. Though, only one observation in the evening in the present trial cannot give any accurate result and the opposite was seen by both Dawkins *et al.* (2003), Rault *et al.* (2013) and Bubier and Bradshaw (1998) who saw a higher number of hens in late afternoon and evening.

5.5 The poultry house and light intensity

During the trial the light intensity both inside the poultry house, in the winter garden and outdoors was measured on one occasion on each farm (Table 10). Farm 3 had the highest value of lux both at pop-holes and in the winter garden compared to the other farms. The farm also had the highest number of hens outdoors and one of the reasons could be the lower difference in light intensity between the indoor and outdoor environment, possibly decreasing the fearfulness of entering the range. This is in accordance with findings by both Gilani *et al.* (2014) and Dekker *et al.* (2012) that more hens went outside when the difference in light intensity was decreased between the indoor and outdoor environment. It should also be kept in mind that it is a great difference between <10 lux at the feed tray and >50 000 lux outdoors seen at all farms in the present trial and that it therefore might be one of many reasons why the percentage of hens outdoors was low on all four farms. Farm 4 showed lowest lux-levels at both pop-holes and winter garden creating the greatest difference in light intensity between indoors and outdoors. That farm, also as mentioned several times, had the lowest number of hens outdoors, which confirms this further.

According to Bubier and Bradshaw (1998) the number of hens outdoors increases when feeding them *ad libitum* with roof suspended feeders instead of fixed feeding times with feeder belts. In the present trial all four farms used feeder belts that were switched on five to six times a day. Since all four farms had the same feeding system its impact is not possible to analyse. However, it is of relevance to consider that changing feeding routine could improve the movement of hens outdoors. Bubier and Bradshaw (1998) concluded that hens kept close to the poultry house in conjunction with each feeding time increased their movement from the range back into the poultry house.

5.6 Impact of plumage condition, hybrid and age

Bestman & Wagenaar (2003) and Shimmura *et al.* (2008) stated that if hens have access to an outdoor run the behaviour of feather pecking will decrease. This is also confirmed by Pötzsch *et al.* (2001), Nicol *et al*. (2003) and Mahboub *et al.* (2004) but even if the hens have access to an outdoor area the level of feather pecking could still be high if the ranging is low. It is difficult to evaluate if the hens are unwilling to range when the feathering is poor due to an increased stress level and lower protection against wind and low temperature. An alternative is if the poor plumage condition, on the other hand, is an effect of hens staying inside and thereby increasing the density level of the indoor area, as discussed by Bestman & Wagenaar (2003). This conclusion is though misaligned with the higher prevalence of feather pecking in organic production systems compared to conventional systems where the density is higher.

The plumage condition on each farm was determined through a randomly picked sample of 100 individuals on each farm. On three of four farms all hens were well feathered but on Farm 4 the plumage condition was poor and almost 80 % of the hens had naked spots and 50 % had naked areas larger than 5 cm (Table 9). The feather pecking on the fourth farm had, according

to the farmer, begun soon after the arrival to the farm and the plumage condition was therefore already poor at first access to the outdoor run. The reason for the higher occurrence of feather pecking behaviour on this farm compared to the other three is difficult to say, but due to its early development it is probably a result of poor rearing at the breeding farm. Many farmers lower the light intensity to decrease the level of feather pecking and even if it is not confirmed it is possible that the producer on Farm 4 kept the light intensity on a low level for this reason. A combination of poor plumage condition and the great difference in light intensity between indoors and outdoors is possibly one reason why ranging was lowest on Farm 4.

There were two different breeds taking part in this master thesis. Farm 1 and 4 kept hens of the hybrid Bovans and Farm 2 and 3 had LSL (Table 6). All hens on all farms were white except a small number of brown layers (less than 100 individuals) on Farm 1. No study comparing the outdoor use between the white hybrids Bovans and LSL has been performed and no difference could be seen in the present trial. Farm 1 and 4 with the Bovans hybrid had the second largest and the lowest percentage of hens outdoors respectively while Farm 2 and 3 with the LSL hybrid had the second lowest and the largest percentage of hens in the range respectively.

In Sweden the use of white hybrids is dominating (SLU, 2010) and the use of beak trimming or other mutilations are prohibited (Svenska Ägg, 2014). Some people claim that the utilization of the outdoor run decreases with white hybrids compared to brown (Mahboub *et al.*, 2004; Gebhardt-Henrich *et al.*, 2014). If the low use of the range in the present experiment depends on the use of white hybrids is difficult to analyse due to lack of brown hybrids in the trial. The prohibition of beak trimming increases the risk of feather pecking and according to Tauson *et al.* (1999) this risk is enhanced among brown hybrids kept in loose housing systems such as the organic production. To use brown hybrids in Swedish organic egg production with the purpose to increase the range use might simultaneously decrease the animal welfare.

The hens on Farm 4 in the present study were older, 47 weeks, compared to 25-30 weeks in the other farms (Table 6), and they had both been inside for a longer period and were older at first access to the outdoor run. Both Hegelund *et al.* (2005) and Gilani *et al.* (2014) saw a lower use of the range with increasing of age. A reason for this could be an increase in fear level in older hens (Hocking *et al.*, 2001; Hegelund *et al.* 2005). Zeltner and Hirt (2003) did on the other hand see a increased use of the range when the hens were older, but the number of hens outdoors were however low for all ages. Both Grigor *et al.* (1995) and Gilani *et al.* (2014) saw a correlation between percentage of hens in the outdoor run and lower age at first access.

6 Conclusion

In this master thesis it could be stated that enrichment in the outdoor run tended to be attractive to hens and encourage them to move further out in the paddock compared to areas without enrichment. If placing the enrichment in a straight line or in a zigzag formation has any impact on the distribution of the hens could not be clarified since the hens seemed to prefer both likewise. The present study was on the other hand limited in both time and expenses with a small number of farms. Due to these limitations this study cannot conclude that placing of enrichment is of no importance.

7 Future perspectives

The distribution of the hens in the range needs to be improved both to increase animal welfare and to lower the overfertilization in the range close to the pop-holes. To increase the distribution of the hens the range needs to be designed with protective enrichment to encourage the hens to go outside and it has been proven in several cases that the presence of enrichment increases the number of hens outdoors compared to ranges without. It is therefore more interesting to compare different enrichments with each other as well as the placing. Shelters placed as clusters should be compared with shelterbelts as well as artificial enrichment should be compared with vegetation. More trials ought to be executed on commercial farms since it is where the results will be implemented in the end.

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10 Appendix

10.1 Appendix 1

Calculations made on figures found in Rault *et al.* (2013):

Number of hens near the shelterbelt:

Zone 1: 86.2 ± 6.2

Zone 2: 22.3 ± 6.2

Zone 3: 8.23 ± 6.2

Average percentage of hens near the shelterbelt:

$$\frac{\frac{86.2 + 22.3 + 8.23}{3}}{17000} \quad 0.002 \quad 0.2\ \%$$

Number of hens within the control area:

Zone 1: 14.9 ± 6.2

Zone 2: 2.8 ± 6.2

Zone 3: 2.6 ± 6.3

Average percentage of hens within the control area:

$$\frac{\frac{14.9 + 2.8 + 2.6}{3}}{17000} \quad 0.0004 \quad 0.04\ \%$$

10.2 Appendix 2

Calculations made on figures found in Table 1 in Mirabito *et al.* (2001):

Percentage of hens with access to a range enriched with peach tree orchards:

$$\frac{54.0 + 50.9 + 53.7 + 77.2 + 65.7}{5} \quad 60.7\ \%$$

Percentage of hens with access to a range with no enrichment:

$$\frac{6.2 + 12.8 + 11.4 + 16.9 + 19.8}{5} \quad 13.4\ \%$$

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