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How Do Danish Organic Farmers Use Agroforestry System to Improve the Distribution of Laying Hens: A Case Study on Seven Farms

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Abstract

In big scale production laying hens do not use evenly the outdoor area, also called the run. However the presence of trees can influence the distribution of the birds. Agroforestry systems provide indeed a shelter for the hens roaming outside. In this study 26 runs including flocks of 3,000 organic laying hens and agroforestry systems were investigated. The goals were first to establish a typology of the runs observed and identify the advantages and limits for each type of run. Secondly the study aimed to make a descriptive sheet for each farm, including the thoughts of the farmer interviewed and figure out the features of the run with the best distribution and its type. An important part of the work was also to search in the scientific literature what was already found about the influence the trees and the design runs with agroforestry in Europe. The result of the observations on the 26 runs showed Danish specificities like the presence of a plantation on 78% of the cases, made of an orchard or a coppice for biomasse production and sometimes a forest of firs for Christmas trees production. No specific interest was found in between the type of run including orchard or coppice and the run with the best distribution seem to gather both of the features: presence of fruit on the outdoor area in addition to a plantation of willows. However the factors influencing the distribution of the hens on the outdoor area are multiples and include the density inside of the veranda, the presence of a source of food outside like a field of grains or the fact that the pop-holes are facing the plantation.

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Introduction

Awareness in laying hens welfare has been increasing over the past few years in Europe and consumers are getting increasingly interested in free-range egg production (Vecchio and Annunziata, 2014). However in Denmark as in many other European countries, feather pecking and cannibalism are widespread in systems providing an outdoor area: the mortality rates are even higher than in battery cages (Kjaer and Sørensen). This is partly due to a high density of livestock staying inside the building (Bestmann and Wagenaar, 2003). Indeed many of the hens do not come outside the houses at all or at best stay within the immediate environment of the building, although they can access to a large outdoor area (Zeltner et al. 2011). Furthermore it has been shown that the distribution of hens on the outdoor area, also called the run, is uneven in most of the case. Laying hens tend to stay very close to the pop holes rather than roaming outside and using the rest of the outdoor access: Zeltner & Hirt (2003 & 2008) observed an average of 75% of the hens within 20 m of the poultry house. As a result, less than 25% of the daily droppings are excreted on the outdoor area and the amount of nitrogen in the soil reaches a very high level in the area close to the poultry house (Dekker et al. 2011). Nevertheless if those observations are constant in every poultry farm, variations in the distribution can be observed, depending on various factors such as the breed, the individual, the age, the season and the management of the outdoor area (Ringgenberg et al. 2014, Smith and Bauer, 2014). Among those factors the large discrepancy between the indoor and outdoor environments and the proportion of diverse structures in the run may explain part of the variations in the use of the free-range area (Hirt et al. 2000, Hegelund et al. 2005, Zeltner et al. 2008).

The literature shows that the outdoor range is in general better used when they had more trees or hedges and the number of birds ranging outside is correlated with the percentage tree cover on the range (Hermansen et al. 2005). The trees provide shade from the sun, dry areas for dust bathing, shelter from aerial predators and from ground predators approaching from the side (Nicol et al. 2003). The design of the run has also an influence on the distribution of hens in the outdoor area (Knierim, 2006). For example the distance to access to the vegetation cover is crucial (Hegelund et al. 2005). It is thus still not clear what features of trees are most important to hens since trees are multipurpose.

The present work is a reflection on seven case studies based on seven different Danish organic farms, where the time when the hens are allowed access to the outdoors is clearly specified as well as the size of the outdoor space they may roam. The goal of the study is to:

- Establish a typology of the runs observed
- Identify the advantages and limits for each type of run
- Make a descriptive sheet for each farm, including the thoughts of the farmer interviewed
- Figure out the features of the run with the best distribution and its type
- Compare the findings with the scientific literature

This work is carried out with the Department of Agroecology of Aarhus University, in the frame of the European Project Agforward (AGroFOrestry that Will Advance Rural Development) as part of the Work package n°5. The aim of this Work package is, in part, to identify innovations to improve the benefits and viability of agroforestry for livestock systems such as poultry. One of the objectives is to find out the key challenges and possible innovations to address those challenges, within a Participatory Research and

Development Network (PRDN) related to the use of agroforestry in poultry, ruminant, and pig production systems (Agforward, 2006). Based on the goals written above, the research questions are the following:

- How do Danish organic farmers use trees to improve the distribution of laying hens?
- What do the organic farmers perceive as main challenges and advantages in agroforestry?
- Based on existing knowledge and experiences from practice what is the best practice in relation to layout of the outdoor run with trees?

In the next chapter a literature review will present the state of the art on the design of the run with trees. Then the material and methods used for the investigations will be shown, following be the results and discussions.

2. Literature Review on the Design

2.1 Foreword

This Master Thesis is not focused on free-range broilers but on laying hens and there are important differences between the two types (Dawkins, 2003). Laying hens will live up to 70 weeks and have access to the outdoors starting at point of lay when they are about 16 weeks old (Vestergaard et al. 1993). Broiler chickens, in contrast, have been bred to grow much faster and intensively housed birds are usually killed much earlier: even the slower growing broilers used for outdoor systems live for only 2–3 months and have access to the outdoors for half this time (Kjaer, 2002). This means that a majority of the literature, which deals with broilers, may not be directly applicable to the laying hens' breeds (Uitdehaag et al. 2009). Nevertheless as the laying hens have access to the outdoor area when they are older than the broilers it can be assumed that their behaviour can be overemphasized: since they stayed a longer time inside they will be more fear in the outdoor area than the broilers (Vestergaard et al. 1999). Also the findings in broilers literature like the percentage of birds found outside can be minimize for laying hens. Furthermore the investigation of this thesis will look at birds kept in fully commercial free-range farms with an average of 10,000 hens per farm, which provide typical commercial systems with a quite important difference between the indoor and the outdoor area.

2.2 Role and disposition of the trees

2.2.1 Role and design of the optimal/successful run

Above all, the optimal run aims to protect the chickens from the wind. Then the design is made to secure the movement of the chickens in the run. And thirdly it should provide 30 to 40% of shadow spread over its entire area: a well-designed tree planting scheme which provides good canopy cover is the most practical and sustainable method to encourage hens outdoors and get them ranging further (Le Douarin et al. 2012). Besides of those three main characteristics it contributes to the plant biodiversity -for example with a well managed meadow; provides a resting place of poultry; offers a harmonious picture fully included into its landscape territory; gives opportunities for species-specific behaviours such as foraging and gives well being both to the farmers and the animals. The optimal run is appropriated for each farmer and suitable to achieve its goals (Leroyer and Lubac, 2009).

Protect from the wind

The wind is the first factor keeping the chickens inside and limiting them to go out. It also brings trouble in their movement on the run. The orientation of the pop-holes should be set once the level of exposure to the winds and the prevailing directions have been measured. The implantation of windbreaks is one of the most effective ways to protect the pop-holes traps but also then the intermediate space and finally the furthest area of the run (Béral, 2013).

Secure their movement in the run

When the hen is going out for the first time, it needs a time to discover and learn before the exploration of the largest grassed area. The trees located further than 20 meters from the buildings will not be visited immediately and a large thick area of groves and trees at less than 10 meters from the pop holes is too close and then will limit the exploration. In general it should be avoided to plant trees within 10-15 meter away from the building. On the other hand the hens will not really go further than 40 meters away from the buildings especially if no shade is provided (Lubac, 2006).

The trees and groves should be well distributed over the run and can be added to bare area to lead and bring them to explore always a bit further. However, while the cover very likely provides the hens with an important feeling of safety, at the same time it may enable hawks to hunt more efficiently as they may use the canopy as a hiding place to hunt. However no information is available to know whether an improved cover of the run actually affects the extent of predation losses. Ground predators, on the other hand, can

be controlled relatively easily by good fencing, including an electric fence, and nightly indoor housing (Bestman et al. 2000, Gilani et al. 2014).

Bring the good amount of shade

Once the building and the chickens are protected from wind, the design should also provide enough shaded area, well distributed over the run. The ideal level of ground coverage is estimated at 30-40% where 40% is a maximum. Thus the resulting ideal ratio of shade is in between 30 and 50% of the run (Lubac, 2006). It is necessary to establish continuity from on tree or grove to another. The ideal distance between two shaded areas is about 20 m. A distance exceeding 25-30m would strongly inhibit the benefits, that is to say the use the path by the chickens. It is also recommend to structure the outdoor area with trees and installations providing shade and protection from the sunlight for the hens (Roinsard et al. 2014).

2.2.2. How to design it

This subchapter deals with the designs of each of the following canopies: hedgerows, groves, isolated trees and grass.

Hedgerows

It could be a thick hedgerow, a succession of isolated trees with a straight stem or groves with sufficiently branched. The design is drawn according to the main winds which should be perpendicular to the hedgerows. The path is large enough to allow the tractor and other engine to drive through the field (Zeltner and Hirt, 2003). The space in between each row is at least 10 meters to favour the growth of the grass. The main goal is to break or slow the wind down close to the barn but let the air blow above in order to refresh the building in summer. Since a windbreak protects a distance corresponding to 10 to 15 times its height, it doesn't need to be very high: three meters are enough (Zeltner and Hirt, 2011). Planting the hedgerows in a fan shape instead of in straights lines is even better to spread the chickens far away. The trees are planted close from each other -about 2 meters- and then the space in between get wider. For example with a run from 1.8 to 2 hectares with a building of 400 m², the average in South of France is 400m² of hedgerows in lines (Lubac, 2008).

Groves

Planting groves with shrubs species on the edges of the run will create graduated woodland along the run and encourage the birds to explore it. It also acts as a wind break, makes the area warmer, and provides a better distribution of the shade. However, it is better to prune regularly and cut the lower branches of the shrubs which are in contact with the ground vegetation such as grasses. In fact this spot under the shrubs is very used by the chickens and if it is to close because of the branches it can encourage the hens to lay outside (Lindhard Pedersen et al. 2004). The groves are small wood from 100 to 200 m² and they must be protected at their periphery without any entry -except for maintenance- at least during the first ten years. They gather pretty low development species with fast growing ones and should not be planted further than 25m away from any other structure. Shape and orientation should be designed depending on the main winds and shade requirements (Béral et al. 2014).

Isolated trees

Single trees can be isolated or included in an alignment. They are forest vocation species. They produce wood, shade and byproducts like fruits. They also play a guiding role in moving the hens on the run. The plantation should be designed to allow mowing the grass between rows (Smith, 2014). The distances in between isolated trees are narrow enough to encourage the hens to run from a shaded place to another one. Fruit trees should not be too close from the barn to avoid overcrowding. Groups of trees close to the shed offer easily accessible shelter; trees planted on the perimeter a long distance from the shed provide screening and shelter, but may be too fare for the chickens (Markussen and Petersen, 2013). If they are

planted in alignment, the different lines can be planted every from 2-3 meters to 10-30 meters apart in the rows. On the same line, the trees can be planted with a higher density, with a space of 3-8 meters between each. They must be protected individually. If the space between each of them is larger than 10 meters it is likely that these trees will not be enough to protect the wind, but they can be combined with other internal hedgerows (Markussen and Johansen, 2014). The space between each line is from 4 to 6-8 meters but it depends on the trucks and equipments of the farm used for the maintenance. The width of the tractor and its mower is thus important, especially at the end of the rows for tractor turning. Planting with a narrow space like 4-5 meters between each line will strongly restrict the movement of the tractor between the rows (Le Douarin, 2012).

A minimum requirement of 20% of tree cover is needed to qualify as woodland according to the European regulation. So if the farmer prefers regular and easy to manage lines, then the ideal spacing is 2-3m between rows. Planting at this density will require future thinning and pruning when the canopy will be closed but will become a so called 'woodland' faster and could provide an early source of firewood (Leroyer et Lubac, 2009). A good maintenance should lead to a canopy closure within about five years. If they are planted in rows to make management with machinery possible, it is better to avoid too straight lines which look like a strict network; a bit wavy shape will look more natural. Alternatively, it is possible to plant small groups of trees at irregular spacing of 2-3m leaving larger spaces between the groups for the birds to roam through (Markussen and Johansen, 2014).

Grassed areas

On the bare area without any trees, grass can be sown or the farmer can let the natural wild vegetation grow. Nevertheless it is easier to manage with a seeded grass. Grass or wild meadows can be move a few times a year or choose to let the hens do the work. In this last case, there will be area of bare soil mostly close to the barn (Hegelund, 2006).

Mosaic planting

Mosaic planting is inspired by the design of natural mosaic stands in a wild landscape. There are groups of different species forming an irregular mosaic. There is no need to do other weeding than what chickens do. Such a management will eventually provide a high level of biodiversity. This design also brings an aesthetical aspect to the run with a rich and diverse insect fauna which was primarily not on the run. A single group can include both local and exotic species (The-Woodland-Trust, 2014).

Module planting

Planting in module is also based on the natural mosaic stands, but makes it more systematically than mosaic planting. The kind of trees and shrubs are used in groups, preferably with room for clover grass or weeds growing in between. This makes the maintenance of the area easier. Modular Planting is a way to design poultry runs which can be apply to the whole run in many farms. It can be used in narrow, long or wide runs. Nevertheless the modular system is not a system where the modules can simply be copied. It should be adapted to the specific conditions of the farm (Hermansen et al. 2005). Among the species which are the most used in module planting, the willow holds a prime position, partly because it is growing rapidly, partly because most types of willow catch nutrients from the hens quite efficiently. The willow planted in such a pattern has common purpose with the willow planted in a row within a thicket or a coppice, but also bring other functions. Both designs can be used on the same run: the farmer can establish a module plantation in one part of the run and have the other part planted in a row. It is of course also possible to have all the run designed as Modular Planting (Markussen et al. 2013).

Row planting is the traditional way to plant forests, groves and hedgerows. It is simple and straightforward. It is often designed with only single specie and in some cases just even one clone. In West European farms willow or poplar are commonly used. When there are several runs on a farm it is

interesting to design those plantations in various ways. This can be practical, inexpensive and easy to maintain. For example a run can be design with straight rows and equal spacing between the rows like 1.5 meter. Another one can be in a fan-shaped type, which gets longer and longer space between rows as the chickens are progressing in the run. A third solution could be a single modular system with larger groves in modules but denser and larger pasture in between them (Béral 2013).

Path system

It is helpful to get inspiration from the nature in order to design a successful path. Such a design includes different kind of arrangements, both through row plantings, modular systems and real mosaic planting. A network of paths is designed to let customers and visitors get closer to the hens without necessarily interfere. At the same time the path system both helps to make the run more attractive and to enhance biodiversity of the chickens (Zeltner and Hirt, 2012). The path system is developed by Ingeborg Holm on her farm and initially thought especially for it, but the plants and a similar path can be used in many different poultry farms. The system of footpaths can also be made by utilizing old plantations, for example to create a path with soft lines. A wrinkle path will not fulfill the purposes and will seem artificial (Hubert-Eicher and Wechsler, 2001).

2.2.3 Choice of the species

The diversity of plant species present on the run may encourage pecking, scratching and harvesting of seeds. The diversity of the vegetation also lead to the diversity of the run more generally. With a more diverse vegetation the amount of small animals such as insects or worms will increase, which may stimulate hunting and digging. The species on the run should provide opportunities to perform foraging behaviours as it is a high priority (Gebhardt-Henrich et al. 2014). Insufficient opportunity for foraging behaviours is widely considered a cause of the severe problem of feather pecking (Kjaer and Vestergaard, 1999). An optimal run has flowers and/or fruit at all times. It is also of great interest to combine high and low vegetation, like groves, small shelters or grass –any kind of herbaceous production is very interesting to attract the chickens and answer to their need for a shelter. For example lighten copses of broad-leaved trees, pines and ferns. Very short rotation coppices have a positive influence on the behaviour of the birds (Pedersen et al. 2005). The use of green manures and nitrogen-fixing legumes is essential to catch and slow the nitrate and phosphorus leaching process down. Choose local and various species for the trees is important regarding to the adaptation to the environment. In the modular system described above the species are chosen in accordance with the growth speed and the life time of each species (to avoid gaps in groves or hedgerows). Thuja and cypress should be avoid or at least lower than twice the height of the barn. If they are too dense, too close to the building and exciding the high of the fresh air entry they will stop the ventilation process and the stream of fresh air inside the building. They need to be pruned frequently, have a short life time (20 to 30 years) and can create allergenic effect (Johansen, 2012).

There are multiple and diverse solutions for the choice of the plant species and it should be different for almost each farm. But as written above, the monoculture should be avoided: whether for hedgerows, groves or trees, a mix of species is the best choice for an optimal design. The diversity of the sizes, the date of flowering and leafing brings harmony in the landscape through the seasons. This diversity also gives the assurance that at least a share of the population will survive in the event of illness or weather conditions (Hegelund and Sørensen, 2007). To start, the best way to select tree species suitable for a farm site is to look at what is already growing well in the neighbourhood. This gives a good idea of which species suit the local climate, ensuring a better chance of survival and a good integration in the landscape. To know the type of soil is also important to choose adapted species (Le Douarin et al. 2012). In England, the Woodland Trust recommends to plant one hundred percent of native tree, but advice nevertheless non-native poplar like white or grey poplar, or hybrid varieties, in order to establish a canopy cover quickly

(The-Woodland-Trust, 2014). In this area the fastest growing native species are birch, alder and willow. They are also native in some area of Denmark, like south Jutland.

2.2.4 Grassland

In an optimal run, the area between the trees and hedgerows, which can be seen as the grassland area, consist of an association of high (more than 3 meters high) and low (30 to 50 centimeters) like groves, small shelters or grass, herbaceous. For the choice of the grass species, if the farmer seeds, the grass should resist to a maximum under the stamping of the chickens, especially where they are standing very close to the barn (Yates et al. 2006).

Implementation and management

The vegetation should cover the bare ground on the run to a maximum. This will prevent the area to become too muddy and unhealthy and will be more attractive for the hens when the grass will produce grains. The meadow is the mostly sown in most of the farms (Smith et al. 2012). But it is also possible to seed crops such as sunflowers, wheat and corn or any forage production. In any case it will help to clean the ground, limit pool water which are favoring the development of germs or intestinal parasites. It will also promote the degradation of droppings and the absorption of nutrients especially nitrogen and phosphorus (Dekker et al. 2011). The type of grass should be strong enough to resist the stomping of the hens. But if the degradation of the very used area will damage the grass for sure, it is possible to fence some part of the run to protect them from stomping and allow the growth of the flowers. A turnover between two or three protected seeded area for each run is the best option, but over-seeding annuals or perennials could be solution on the most used parts of the run (Borin et al. 2009). To diversify the meadow and reduce nitrate leaching it is also possible to use legumes such as white clover, unless it catches mainly the atmospheric nitrogen (Aronsson and Perttu, 2001). For the furthest parts of the run a mixture of species adapted to mowing, covering and productive is the best option if the goal is to use it as forage to spread in the barn during the winter. Nevertheless the species suitable for mowing are generally less resistant to stomping, but the less explored parts will not face a high density of hens (Hegelund and Sørensen, 2007).

Maintenance

Maintenance can be done when the coop is empty for health reasons for example. A well maintained meadow will lead to a well and almost fully used run. A non-maintained run with too high grasses will be hardly exploited by the hens (Leroyer and Lubac, 2009). The meadow tends to be a bit forgotten over time: non-harvested grass could get low quality. The grassed area at the exit of the pop-holes is often damaged with the over-load of chickens especially if the run is not very well designed. Wheat and barley will not replace the meadow but can bring some positive aspects anyway.

2.2.5 The plantation: orchard, willows and poplars

Willow and poplar are suitable for the chicken coop. Willow and poplar is not very much time or effort. In addition to it, growing willow and poplar is fast so the hens do not just eat the new shoots. It is not the case with firs. It is good for the environment to plant willows and poplars in the hens coop, because it reduces nitrate and phosphorus leaching. Also the farmers can get an economic advantage in using willow and poplar while harvesting it willow and sell it as biofuels and spread it on the field a source of carbon (Johansen, 2012). The hens' welfare and the design, however, should be more important than yields.

Rules and support opportunities for planting

For perennial energy crops and coppice, the area has to be use with an agricultural purpose with harvest and the minimum area is 0.3 ha. The coppice should be planted a minimum of 7.5 m width. With the conventional cultivation standard double rows 0.75 / 1.50 m the distance must therefore be a minimum of 4 double rows in width. Up to 25% of the plantation can be other trees than the main ones, but they need to be spread out in the vegetation as isolated trees and bushes. The minimum is 8,000 plants per hectare, and at least 2,000 plants per. ha for poplar in pure plantation. For energy production it is recommended areas of over 5 ha to ensure a good economical balance (Johansen, 2012).

Species

The new Italian clones of poplars AF 8 with high yield potential are very used, and suit well to sandy soils. Poplars cannot stand with their roots in water but they have an advantage over the willows, by being more open at the bottom. They constitute no barrier to the hens. If such a strategy is chosen to be planting poplars are harvested in the same way each 2 or 3 years and the wood is chipped (Markussen and Petersen, 2013).

Design and maintenance

To drive with machines for planting, weeding and harvesting is it necessary to have a headland of at least 10-12 meters with no vegetation in front of the plantation. The harvest is from every two/three years to five/six years. To be used by the hens the rows should always be planted perpendicular to the pop-holes in the direction away from the building so that the hens can run along the rows out of the building. The rows should be in the direction of the main the wind otherwise it will act as a barrier for the hens. In any case, it is important that the trees are planted and grown such that it allows the harvest and if wanted to move the grass. This depends on the wishes of the farmers and on their goals (Smith et al. 2012).

Fruits and berries in the run

The investment is relatively large, and the production is labor intensive. It is important to take the climate into consideration when selecting fruit varieties, with different varieties depending on weather conditions. There is a synergy between the two productions, because fruit trees meets the hens' needs for shelter and shade places and at the same time the hens keeps fruit trees free of weeds and take harmful insects. The hens can also fertilize the trees and help to reduce the infection pressure of pests and fungi on fruit trees. However, it is clear that the effect is uneven: furthest away from the henhouse, most hens do not roam as much as within the first 100 meters. It is good to seed clover grass between the trees; it provides feed for chickens and nitrogen for the trees (Patterson et al. 2008).

2.3 The building and its surroundings

Regarding to climatic conditions, the freedom to choose between different environments is important. In free-range systems, the presence of a litter of straw in the hen house leads to increased dust and ammonia levels. This problem may be resolved by offering the possibility to connect the indoor areas with the outdoor run and its fresh air, according to the motivation of the hens. It has been shown that domestic fowl does not only prefer environments with lower ammonia concentrations, but is also motivated to seek fresh air after ammonia exposure (Jose, 2009). In Denmark, in most cases the barns gather more than 3000 hens, and this is the reason why the building has to be shared at least in two parts. There is therefore a need to use more than only one side of the buildings to connect the chickens with the outdoor area. The orientation of the pop-holes should be then east or west, depending on which side of the buildings the flock is located. But because of the strong intensity of the sun in summer, the pop-holes should never completely face south side. This would also mean that the other side would face the north side, which would be too cold for the flock on the other side of the building. The pop-holes should face the run, and it

is better to avoid a design which put the run too eccentric (Kemp et al. 2001). The area between 0 and 15 meters from the pop-holes, in direct continuation with the building, is the first part explored by chickens. If this space is muddy, windy, too hot or too cold, the chicken will not come out of the building REF. It must therefore be healthy, protected from wind and comfortable. It should not be too shady because then the chickens will tend to stay only under the shade and not explore the further area. In this case, the load of feces in this area may be high and represent a potential pollution. Then, this area is only a transition zone (Smith and Bauer, 2014).

2.3.1 The area very near the barn: the ground

The considerable destruction in a short time of actively used runs, especially near the hen house, leads to a less attractive run for the hens, and for consumers who expect a green and not a brown hen run. An issue also linked to this degradation is the hygienic deterioration, e.g. in the form of muddy areas and little pools of backwater. In addition to this, environmental problems of high nutrient loads can arise when no green plants are present to catch the nutrients and the intake of soil by the hens can increase, with concurrent potential problems with soil contaminants such as dioxin (Anderson et al. 2009). Thus for hygienic reasons, the area around the hen house should be designed in such a way that water cannot accumulate, that it can be cleaned after the laying period and that the substrate can be replaced (Udawatta et al. 2002). Practical experience shows that also a covered outside run, so called veranda, is an excellent means to prevent hens from carrying too much mud into the house. It provides a sheltered outside area that can be used even under bad weather conditions (Sinclair et al. 2000). An important preventive measure, amongst other things in parasite control, is the rotation of runs. For an efficient endo-parasitological control, long resting periods before the reuse of any area are probably needed. Unfortunately the Danish farms have a too large scale of production to afford enough land for such a rotation (Kjaer and Vestergaard, 1999). Another solution to avoid an overcrowded area close to the pop-holes was tested in the south of France, with a mesh wire laying on the ground, just in the front of the pop-holes. The results were pretty good and the hens prefer to stay under the veranda or to go beyond the installation, so that the first 5 meters area was not too crowded anymore. But once again this is unfortunately not suitable for Danish farms, since the mesh wire gets encrusted in the ground after a few and the work load to clean it would be too heavy on a large area. So those installations can be interesting to structure well focused and not too wide area (Lubac, 2006).

2.3.2 The area very near the barn: the vegetation

Small low hedges can be planted in the front of the pop holes. They will grow at 5-6 meters from the pop holes, depending and the size of the tractor, if it is needed to dig the ground in between two cycles of production, and are about 10 meters long. The space in between each hedge is from 1.5 to 2 meters. They can be used to lead the chickens further and thus to facilitate the use of the run (Béral, 2013). To get a full benefit the hedges should be therefore be positioned in a fan shape, as explained above.

If the pop holes face the main winds, mostly from the west under Danish conditions, the little hedges can be planted as parallel to the barn. If this part of the run is not exposed to the wind, side by side micro-groves of 4-6 m² may be enough. A progressive development of the height of the vegetation along the run creates the important first atmosphere for young poultry. Also, a special care must be taken to protect the pop-holes from the wind: when a young chicken experiment the run for the first time and suddenly face the wind, it is likely than he will not try to explore the run in the future (Le Douarin et al. 2012).

Encourage ranging

Shrubs and trees at 10m from the building will encourage a greater number of birds outside. As written above in this document, studies show only a small proportion of hens in many large scale units use the range (possibly less than 10%) and of those around 70% will stay within 17m of the house Béral et al. 2014). Well-designed tree planting can encourage use of the range and the hens to range further, which in

turn reduces nutrient load from excretion and parasitic contamination close to the house. If the hedgerows around the barn help to maintain a dry litter and slow down the effect of the cold, they are also providing a shelter for the hens. With no trees or cover nearby, only a few of the bravest hens are venturing out into the range, and all are staying close to the shed (Knierim, 2006).

How

Those trees close to the pop-holes will be difficult to establish because of the very greatest pressure of the hens in the area, but they are the most important as they encourage the hens to range and roam further, provide a screen for odors and could catch nitrogen leaching. They will need to be pruned once the canopies start to be too dense and hinder the ventilation of the building. It is better to plant at a higher initial density to make up for any further losses, since chickens like to eat young sprouts. It is also helpful to protect the young trees with solid fences buried in to the ground (Le Douarin et al. 2012). For the groves, an access to the bunch of trees should be managed to allow the entry for maintenance. And of course the space in between the first trees and the building should allow access to machinery.

The good amount of trees

When a chicken is going out for the first time he needs time to discover and learn before exploring the large area of grass. Thus large area of trees and/or groves very thick within the first 10 meters will be too close and will limit the exploration. It has been shown that only very few hens are going further than 40 meters away from the building especially if no shade is offered, but the plantations and shelters should be distributed all over the run and groves or shelters could complete bare area to guide them and lead them further (Febrer at al. 2006). The lack of connection between the furthest area and the building is a pitfall to avoid when it is about designing a minimal run, with low investment: the hens will not go further than 10-15 meters away from the building (Leroyer and Lubac, 2009).

If there are no trees

But if no trees can be planted closer than 10 meter for practical reasons, for instance to keep an access for machinery, the distance from the henhouse to the trees might be too far for the hens. Corridors with higher grasses, rapeseed, mustards etc. will help them overcome the distance easily. The development of shade-tolerant sward mixtures can persist under the trees (Béral, 2013).

2.3.3 Size and number of flocks

In order to stimulate good use of the outdoor run by the hens, group size and husbandry can be optimized. It generally appears that the larger the groups the less the hens go outside: in studies assessing outdoor range use of laying hens, the number of hens seen on outdoor ranges is inversely correlated to flock size (Johnsen et al. 1998). Also, individual hens in small and medium sized flocks, between 100 and 1500, visited the areas outside the house more frequently and spent more time there than hens from large flocks, from 1500 hens. Foraging behavior on the free-range was shown more frequently and for a longer duration by hens from small and medium sized flocks than by hens from large flocks (Hegelund et al. 2006). The flock size is important for the use of the hen run and therefore we should keep laying hens in moderate flock sizes, around 1500 hens. But even in the smallest observed flock size of 50 hens, only 41.2% of the hens are outside simultaneously. Probably this is due to the fact that time consuming behaviours, such as feeding and drinking, are performed inside the poultry house, and the birds have not the time to be outside for a longer period (Bestman et al. 2013). The lowest mean daily percentage of hens outside reported is 4.0% for a flock of 16,000 hens and the highest 42.1% for two flocks of 490 hens. Dividing flocks into smaller groups is, therefore, a possible measure to improve the run use (Bestman and Wagenaar, 2003).

In Denmark the average flock size is 3,000, that is too say the maximum authorized under the European law. Furthermore the flocks are very often staying in the same shared building. For example a large building can contain 18,000 hens, shared in six different flocks. Nevertheless, the European legislation stipulates that the different flocks should stay in separated buildings, for animal welfare and hygienic reason (Bestman, 2014).

2.4 Use of the run itself

2.4.1 Furthest area

It is the area located from about 30 meters away from the pop-holes until the end of the run. Shelters to protect the hens from wind, sun and predators of the sky is still needed. The design itself will aim to guide the chickens when they are roaming in the run. In the absence of trees, groves or hedges for guiding animals, this area is often unexplored, except sometimes in autumn or spring when the climate is ideal (Rivera-Ferre et al. 2007). It is of course possible to implement a plantation type orchard, willows or poplars for energy production or a basically improve a woodland if it is already there. A combination of those different patterns is also feasible (Le Douarin, 2012).

The orchard must be made with the development of high trees like cherry, apple, pear or plum trees. They may have a trunk quite high to allow the access of machinery. The lowest branches can be used by the hens for perching or eating fruits; this can be seen as good in an animal welfare point of view, but can also have a negative impact on the production on the other hand. Any chemicals applied on the fruit trees should be in adequacy with poultry production, and it is better to forbid the access of the run to the hens while the chemicals are spread around anyway (Johansen, 2012). Some plantations are also repulsive when the vegetation is to dense to get in, like wheat crop seeded at higher density that 200 grain/m². But if not too dense, grain crops can be a good mean to attract the hens outside especially when they go out for the first time. Then it could be also efficient to give them less food inside, to motivate them to search for more food outside (Markussen and Petersen, 2013).

2.4.2 On the periphery of the run

Peripheral hedges especially have the function of creating a real protection against the wind and provide shade. Coniferous or evergreen hedges like laurel palm, cedar or cypress are not recommended because they create whirlpools and can host undesirable species like starlings. Deciduous hedges are effective on their entire height when they are permeable up to 50%. A mixture of species, 5-7 minimum, is very suitable for the biodiversity and the resistance to diseases. They can slow the wind speed down of 60% and level microclimatic differences: cold temperatures and heat wave (Roinsard et al. 2014).

2.4.3 Diversity and distribution of the shelters

To get a better distribution of hens over the run and also to reduce run destruction and hygienic deterioration, well-dispersed cover and stimuli are clearly effective (Horning et al, 2002, Zeltner and Hirt, 2003). Artificial structures have the advantage that they can be moved, enhancing an even use of the run. In general, such structures should provide additional stimulation for natural behaviour such as dust bathing or foraging, provide shade or protection from winds and possibly from predators. Hens may not prefer to stay close to the building when more area in the further parts is covered with shelters. Shelters can be built before the growth of the trees or when the soil is not favorable (Volk et al. 2006).

Diversity

In addition to the tress, any random shelters are very often welcomed by the chickens. For example if the breeder let some piles of old tires, metallic sheet or cinderblocks on the run, he will likely notice that the hens like to peck and scratch around it. Nevertheless those kinds of random shelters are also a good shelter too host predators like weasels or foxes, and can be also a way to contaminate the chickens if they from little pools and contain backwater (Lee and al. 2003). So a random shelter other than vegetation should be implemented with a special care in no way are a pile of rubbish. This is essential for direct farm sales or for any activities Home on the farm as well as for the image of an organization of the production. With a certain number and diversity of structuring elements in free-range systems, more hens are attracted to using the hen run. Unless there is no big influence of the amount of structures on the use of the hen run, but the hens prefer the part with various structures. Variety is thus more important than having the area covered by structures (Zeltner and Hirt, 2003). Also when almost the whole surface of the hen run is not covered with a structure it is crucial to have no more than 10 m walking distance between structures (Zeltner and Hirt, 2012). The advantage to not having a structure which could be regarded by the hens as a dense forest, like maize, is that hens have better visibility, which makes it less dangerous for hens staying outside at night as there is less danger of predation, for example by foxes (Gebhardt-Henrich et al. 2014). On the other hand, Hegelund et al. (2005) observed in their study in Denmark that weather conditions have a greater influence on the number of hens in the run than in tents. In an earlier study Zeltner and Hirt (2003), found that a simple artificial structure like a roofed box with sand in the hen run has an effect in the distribution of the hens, as more hens were on the farther parts of the hen run, whereas scattering grains on the range area had no effect on the number of hens in the run.

Distribution

Birds tended to emerge earlier, and spend less time inside the box, when a feeder is present in the outdoor area, but tended not to disperse further than the point of the nearest feeder (Zeltner and Hirt, 2012). To obtain a more equal distribution of the hens in the free-range area, it is important to have an equal distribution of structures. It is also important to look for suitable positions for the different kind of structures. The most attractive structures should not be situated close to the poultry house. However, the attractiveness of a specific structure may be individually different. It is also known that some hens are never observed outside the poultry house and some spend most of their time in the hen run (Keeling et al. 1988). When different structures are available, hens are mostly close to the ones which provide shelter and shade. These results show the hens' great need for anything they consider a structuring element. The most attractive structures should not be situated close to the poultry house.

2.5 Farmer's concerns for the future

2.5.1 Weed control

Weeds are usually one of the main reasons a culture of willow or poplar not succeed as intended, and competition from weeds can cause extremely large yield. Weed control is therefore essential to establish a good stock of trees and secured a good growth, whereby charcoal trip will eventually be able to compete with weeds. The particularly in the year of establishment, and in the second growing season, to weed control is required (Leroyer and Lubac, 2009).

2.5.2 Mulching

Mulching is sometimes used for weeding but this is not recommended if the main goal of the farmer is to keep the weed away, because the birds will scratch and remove it, and mulch mats are often pecked away by the birds within a year. But it will be a good opportunity to get worms so additional proteins and

diversified healthy food. Mowing or topping between rows of trees, like in a plantation, deters birds from laying outside (Béral et al. 2014).

2.5.3 Protection of the trees

The young and newly planted trees must be protected with suitable guards or a whole fence if it is a young plantation of firs or willows. The fence needs to be well buried into the ground, ideally a third of its length, with the top of the net just below the top of the post. Spiral tree guards are unsuitable as the hens can peck through the gaps in the spiral and kill the tree (Lubac, 2006). Also avoid mesh and combined mesh/plastic type guards as again the hens can peck through these. The height of the guards is critical as they need to be tall enough so the birds can't jump on to them and peck the tree inside. The best height is a minimum of 75cm, but if you also have deer, use 1.2m tubes. If livestock are located close to planting areas, they will need to be fenced off from the young trees with post and wire fencing to prevent them from eating the trees (Roinsard et al. 2014).

2.5.4 Pruning

To plant is the easiest thing to do. It is more difficult to manage the pruning, especially the firsts years (Béral, 2013) Prune the early years to avoid hedgerows in a "V" shape. For example one year after the farmer planted the first trees, the pruning should be done at 10 cm above the ground; this will help the production of many branches and thus will help to thicken the hedgerow. They should be pruned at 30 cm above the ground the second year. If there is no pruning the following years the amount of species can be reduced by half. It has to be maintaining frequently to balance the amount of each species, especially in groves (The-Woodland-Trust, 2014).

2.5.5 Adaptation to the farm

In a first step the farmer can focus on the building on its surrounding, the periphery of the run, the area close to the pop-holes and intermediary area. The furthest area can be design and improved later. The design and the planning should be adapted to each farm, soil, climate, wind, and local species (Smith et al. 2012). On one course to another the inventory may be different and then requires nuanced choice. The farmer can technically be accompanied at various steps. This course includes thoughtful amenities between each space with connections there between. They are adapted to environmental conditions and line with the affinities of the breeder (Yates et al. 2006). There is a need for an adaptation to the soil and the climatic situation and the wishes of the farmer. There is no such thing as a general pattern or a typical design (Jones et al. 2006). The design of the course requires good knowledge of the conditions soil and climate: texture, percentage of organic matter, deep soil, stones load, depth of water, water logging, rainfall, frost, etc. The choice of species will directly be related to those criteria and production goals targeted. The best is to look at the surrounding vegetation (The-Woodland-Trust, 2014). And also it is always a good help to get support from more experienced farmers.

2.5.6 Goals

The run is a production area. If he can procure animal welfare, it can also produce grass, fruits and wood in various forms. It can contribute to the making fence posts, power plate or wood log. The inventory should help target production targets and the means to deploy achieve these goals. Multi-purpose trees concept means having multiple uses for individual trees within the farm landscape. To qualify, besides the primary design use, a tree can also have a number of secondary uses (Williams et al. 2012). Living fence posts can, as a secondary output, be pruned to provide leaf fodder and the pruned branches can also be use for firewood. In addition to increasing land-use efficiency of a system through multiple uses, multi-purpose trees, used as selection criteria for woody perennials, can provide some degree of flexibility in an otherwise rigid design. Tree species that can provide biomass for use as green manure or as fodder, would be selected (Montagnini and Nair, 2004).

3. Materials and Methods

This chapter is divided in four parts aiming to answer the goals presented in the introduction. The figure 1 summarized this reasoning.

Materials and Methods	Corresponding Goals
1. Choice of the farms	• Make a descriptive sheet for each farm, including the thoughts of the farmer interviewed
2. Observations of the design	• Establish a typology of the run observed • Make a descriptive sheet for each farm, including the thoughts of the farmer interviewed • Figure out the features of the run with the best distribution
3. Interviews	• Establish a typology of the run observed • Identify the advantages and limits for each type of run • Make a descriptive sheet for each farm, including the thoughts of the farmer interviewed
4. How to assess the distribution of the hens	• Figure out the features of the run with the best distribution

Fig. 1: Materials and Methods with the respective corresponding goals.

3.1 Choice of the farms

- Based on the list of the Danish organic farmers with laying hens, the runs where tree were planted were checked on Google Map.
- The farmer owning a run with trees were contacted via phone call and e-mails and asked if they were interested in participating in the survey.
- Among the farmer potentially interested, seven were chosen for the case studies because of similarities in the climate. Furthermore all the farms selected are located in Middle Jutland and the hens were at least 25 weeks old.
- To avoid big variation in the climatic condition the data were collected during a short period of time, late in spring during 3 weeks from the 28th of May to the 11th of June. The time of the year can affect the distribution and in general more hens prefer to stay inside during the winter and the summer and experiences show that there are more hens in the outside area in spring and in autumn (Zeltner and Hirt, 2008). However the Danish weather can change very much from one day to another, as said above, and to control the weather factor, the temperature, the cloud cover, the wind speed and the wind direction were recorded, for each scan. Indeed the hens roam less when it is too windy, rainy or sunny.
- Five farmers out of the seven were already involved in previous surveys about the use of agroforestry to improve the use of the outdoor area. The findings of those works can be found in the following literature:
    - "Improved outdoor areas in organic egg production", in Danish. It is a result of a project conducted over a three-year period from mid-2001 to late 2004 by collaboration between egg producers.
    - "Design and operation of poultry farms: construction, maintenance and operation of the chicken farms, better utilization of resources in organic egg production"

3.2 Observations, interviews and assessment of the distribution

The figure 2 summarizes the information collected during the survey on the field and with the farmer.

Methods	Sub-part	Information collected	
Observations of the design	General data on the use of the run	Date of arrival on the farm	
		Period when the run is empty	
		Presence of a feeder outside	
	Veranda	Size of the building and average density per flock	
	First zone, from the building to the first trees	Orientation of the pop-holes, presence of a large opened door	
		Artificial soil and its origin	
		Number of diverse structures on the area	
		Distance of the first trees form the building	
		Name of the species of the trees	
	Transition area, in between the first area and the plantation	From and until which distance does the grass grow and its state of development and degradation	
		Management of the grass (cut, crashed, harvested…)	
		Nature of the seeds (grass, clover, corn, sunflower, mixtures…)	
		Assess if the pop-holes face the plantation	
	Plantation	Nature of the plantation: purposes and species	
		Presence of a fence to protect the young plantations	
		Distance from the pop-holes to the plantation	
		Mean distance in between each tree	
Interviews	Thoughts of the farmer	For how long time does she/he bread chickens?	
		When do the trees started to be efficient?	
		Global perception of the run: ○ *positive* ○ *negative* ○ *no answer*	
		If she/he would have to do it again, would you do it differently? ○ *Yes* ○ *No* If yes, what would she/he change?	
		Did she/he observe any changes in the behavior after having modify/maintain the run?	
		Role of the trees according to her/him	
	The hens	Age of the hens	
		Breed of the hens	
		Climatic condition	
		Number of hens per flock and number of flocks	
How to assess the distribution of the hens	What to record *(the number of hens found outside can be divided by the amount of hens for the whole flock to get a percentage of hens outside)*	Distribution: the numbers of hens over the four different zones of each run were checked on one day at 4 different moments: 10:30 am, 2:00 pm, 3:30 pm and 4:30 pm.	
		The activities (dust bath, exploring, roaming) and the location of the hens during the scan sampling over the different zone of the run	On the meadow or grassland
			Isolated trees
			Artificial shelters
			Hedgerows or groves
			Fences
	How to record	Approach the run from the end and while being hidden	
		Estimate the distribution within less than 10 minutes	
		Take a lot of pictures and also at a chicken's high	

Figure 2: Information collected and corresponding methods.

4. Results and Discussion

This chapter presents the result and discussion of a descriptive study on the use of the outdoor area in Danish laying hens' organic production. The four goals presented in the introduction of this work are addressed in a qualitative analysis in four parts:

- A typology summarizing the six different types of runs observed in Denmark during for this study.
- A table identifying the advantages and limits for each type of run.
- Descriptive sheets of the 7 seven farms visited including the 26 runs observed. This chapter presents an extract of the most representative farms, n° 1, 4 and 5, gathering all the types of run observed. The farm n°1 is the first farm visited and so on. The other runs are shown in appendix.
- A discussion based on a benchmarking analysis, comparing the run with the best distribution observed, the run 4A, with the other runs. The findings are compared with the scientific literature from the literature review.

4.1Typology of the runs seen in Denmark

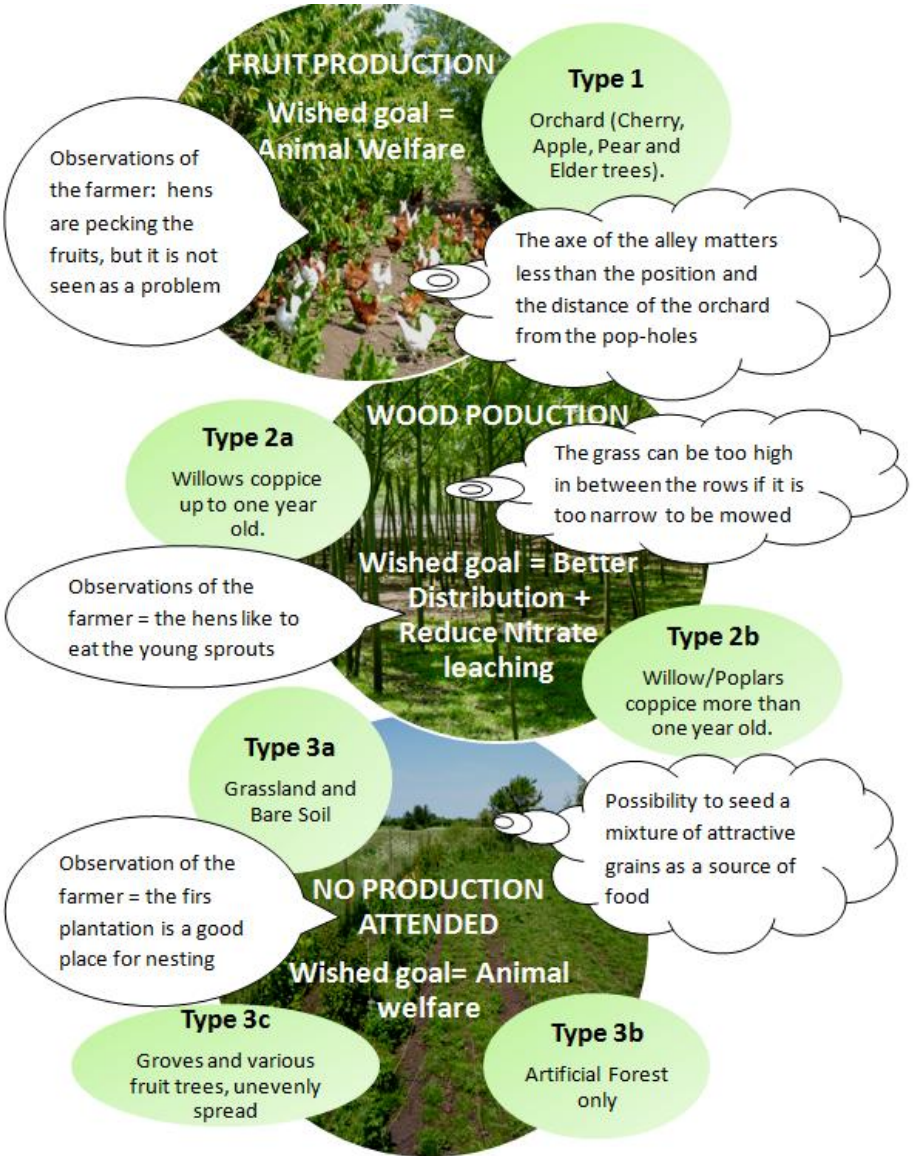


Fig. 3: Typology of the run seen in Denmark based on the observations and farmers' thoughts.

4.2 Advantages and Challenges for types of run observed and descriptive of each run

Type of run		Advantages	Limits
FRUIT PRODUCTION Wished goal = Animal Welfare *(36% of the runs observed)*	Type 1: Orchard (Cherry, Apple, Pear and Elder trees). *Runs observed: 3a, 3b, 3d, 3e, 5a, 5b, 5c, 5d, 7c*	• Possibility to move the grass in between the rows. • Hens are chasing the moles which eat the roots of the trees. • Start to be efficient from day one if the trees are already a few years old when they are planted. • The axe of the alley does not really matters (3a, 3b). • Very attractive for the hens; hens like apples and cherries.	• For the best efficiency the hens should enter the run just before the harvest when the fruit are really attractive (the fact that the hens like to peck the fruit is not seen as a problem by the farmers interviewed)
WOOD PRODUCTION Wished goal = Better Distribution + Reduce Nitrate leaching *(40% of the runs observed)*	Type 2a: Willows Coppice up to one year old. *Runs observed: 6e, 6f, 7a, 7b*	• Start to be efficient from day one if not protect with a fence at the beginning. • The young shoots are attractive and the pruning is very useful for the following years: no branches will grow on the ground level.	• Hens like to eat the young sprouts, which slow the growth down. • Could be necessary to protect the plantation with a fence at early stage.
	Type 2b: Willow/Poplars Coppice More than one year old. *Runs observed: 1a,, 4a, 4b, 6c, 6d, 6e, 6f*	• In the old coppices they are looking for the shelter provided • Catch nitrogen • Start to be efficient from day one • No high grass because of the possibility to mow easily	• Weeding difficult to do but needed when the light can reach the ground. • Depending on the season?
NO PRODUCTION ATTENDED Wished goal = Animal welfare *(24% of the runs observed)*	Type 3a: Grassland and Bare Soil. *Runs observed: 1c, 2a, 3c, 4b, 4c*	• Hens can practice dust bath. • Possibility to seed attractive grains like sunflower and corn.	• The seeded area should be protected with a fence. • Short time for the grass to grow in between two cycles of production.
	Type 3b: Artificial Forest only *Runs observed: 1d, 2a, 6a, 6b*	• They practice dust bath once they are in the artificial forest. • Cypress and Thuja grow better than Firs. • Young firs are very appreciated for their sprouts. • The forest is good for the growth of nettles and the hens like its shelter.	• Need to weed under the trees over the first years and it is not easy. • Firs for Christmas trees: the hens like to peck the young sprouts. • Good place for nesting.
	Type 3c: Groves and various fruit trees, unevenly spread *Runs observed: 2a, 4a, 4b, 4c*	• No high grass because of the possibility to mow easily (hens like it more than tall grass according to the farmers). • High attractiveness of the groves with small red fruits.	• Low growth and highly attacked by the hens.

Fig. 4: Advantages and limits for each type of run.

4.3 Descriptive sheet n° 1

1. Jan Volmar and Birgit Hoffmann, visit on the 28th of May in Brande, 4 runs, 12,000 hens, Lohmann Brown, 40 weeks old

Management: The first trees were planted about 20 years ago, first of all to reduce nitrate leaching, then to provide shade for the hens and last to reduce feather pecking. The farmer said that if he would have to do it again, he would plant with a lower density.

Trees: Birch, Blackthorn, Cherry Tree, Hazel, Oak, White willow "Germany", Sycamore, Alder, White Poplar, Elder, Fir, Ash tree, Alder, Beech.

Scan sampling analysis: Although the hens seem to go quite far in the runs A, B and D, then run located at the back of the building is not very used. There are actually almost no trees on this run and the rare hens roaming further than 20 meters are walking along the fence, close the a firs forest. Furthermore the pop-holes on the run are facing a fence after 12 meters.

Fig. 5: Location of the run with an aerial view and main information recorded on field, farm 1

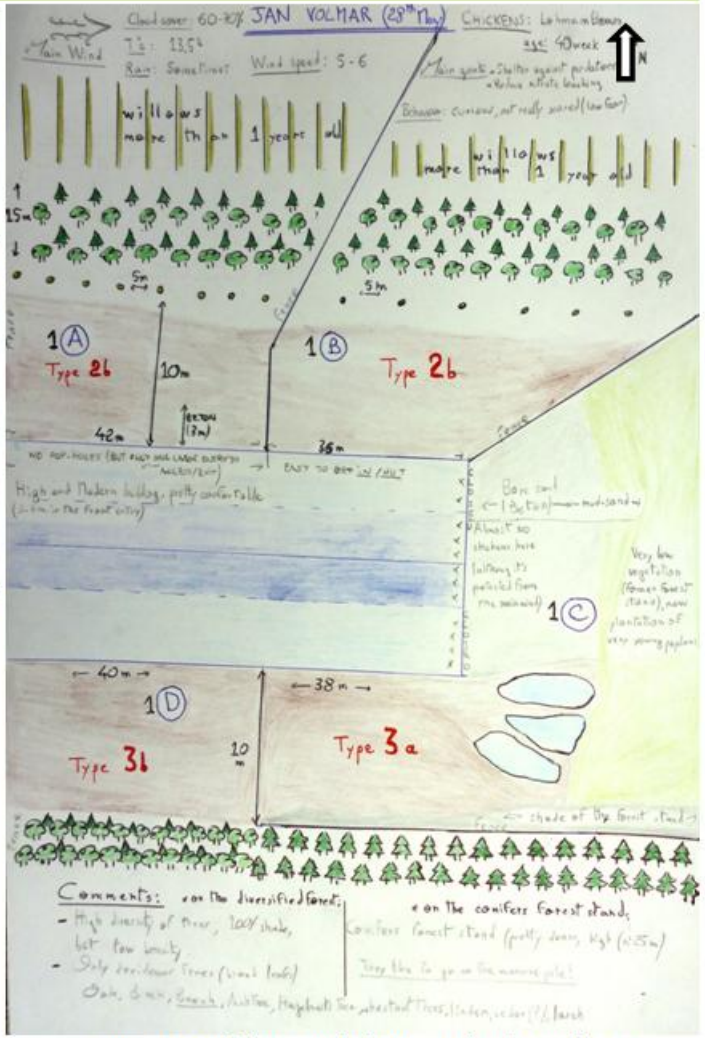
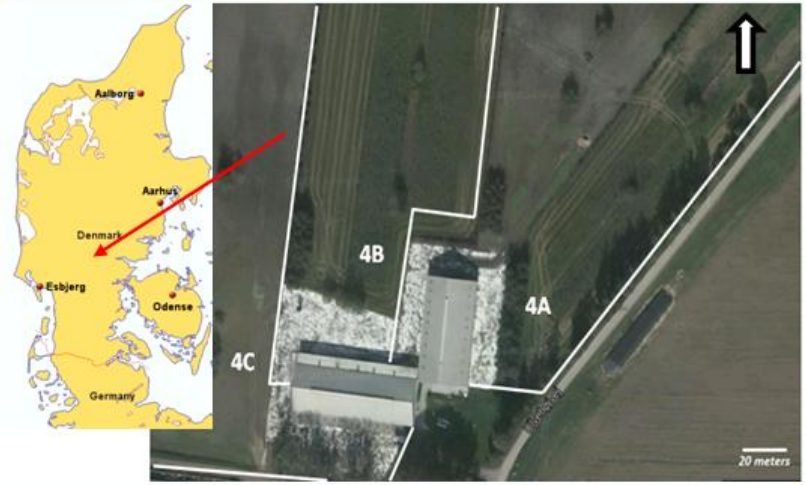


Fig. 6: General design with the types of each run, farm 1

4.4 Descriptive sheet n° 4

4) Ingeborg & Brian Holm, visit on the 5th of June in Brørup, 3 runs, 9,000 hens, Lohmann Brown, 43 weeks old



Management: This farm is the only one of the study to not have a multi-tier system. The first trees were planted about 5 years ago, first to get more hens outside, secondly to catch the nitrogen from the droppings and thirdly to avoid soil erosion and small pools of standing water. The farmer also seed grass, wheat and flowers. Some parts of the run are temporally protected with a fence to let even more time for the meadow to grow. The run A is described in details in the following part, "Benchmarking analysis"

Trees: Birch, Blackthorn, Dogwood (*Cornus sanguine*), Hazel, Maple field, Oak, Yew, Plum, Sycamore, Walnut, Alder, White Poplar, Elder, Pear, Cherry, Apple trees and White Willow.

Scan sampling analysis: For the run A, which seems to be the most used the scan sampling shows that the number of hens is not decreasing but increasing while going away from the pop-holes.

Fig. 7: Location of the run, aerial view and main information recorded, farm 4

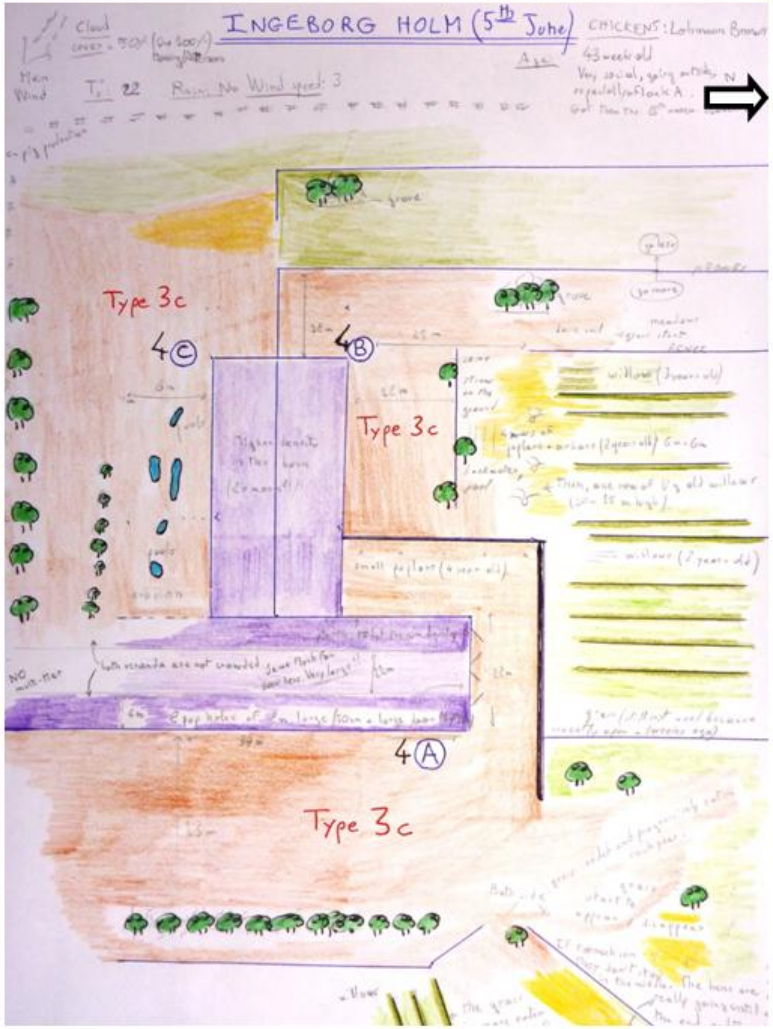
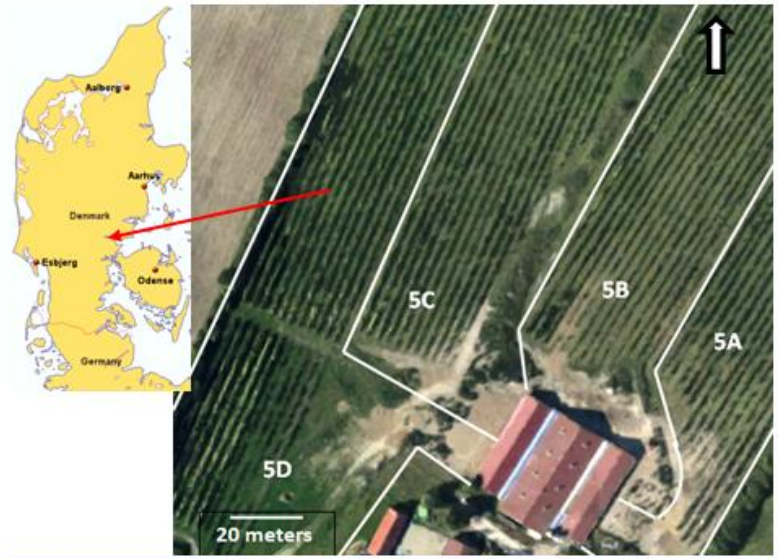


Fig. 8: General design with the types of each run, farm 4

4.5 Descriptive sheet n° 5

5. Jette + Bent Jørgensen, visit on the 8th of June in Børkop, 4 runs, 12,000 hens, Lohmann White, 40 weeks old



Management: The orchard has been planted seven years ago, for the welfare of the hens. On each run there are many spots of nettles, especially within the first 20 meters after the pop-holes. According to the breeder they like its shelter. Red clover is seeded to prevent nitrate leaching. Last year they harvested 17.000 tones of apples. The breeder noticed that hens like to peck the apples (from the bottom). They do not see it as a problem.

Trees: Hazel, Maple field, White willow, Sycamore, Fir, Apple and Pear.

Scan sampling analysis: Presence of stomping clues quite far in the orchard, until the fourth part. About the run situated at the corner of the building and where the pop-holes are not facing the orchard, the run B, the hens were mainly staying in the first 10 meters of the run.

Fig. 9: Location of the run, aerial view and main information recorded, farm 5

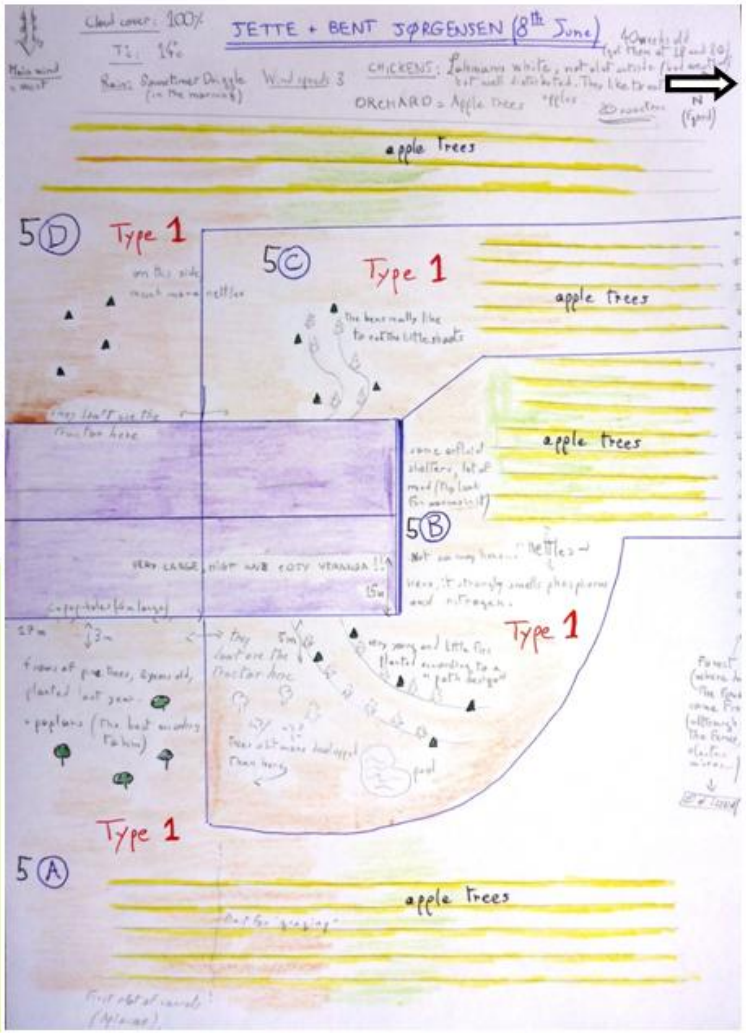


Fig. 10: General design with the types of each run, farm 5

4.6 Discussion based on a benchmarking analysis

From the observations of 26 runs distributed on the seven Danish farms of this study it emerges that the distribution of the hens over the outdoor area is very different from one run to another. Furthermore the number of hens found outside was highly variable from one flock to another: from 30 to 880 hens that is to say from 1 to 30 %, with runs welcoming flocks of 3,000 hens. Big disparities in the design and in other factors such as the age of the hens or the management of the henhouse were noticed in between the runs. The observations on a run where both the best distribution and the higher number of hens outside were observed is presented in the following chapters and compared with the other runs. This run is the run 4a visited on the 5th of June in Brørup, south of Denmark. The hens were well distributed: 81 from 0 to 5 meters away from the building, 300 from 15 to 3 meters and 500 hens after 30 meters away from the building. And the total amount of hens outside, 880 hens, is higher than the average for the 26 runs which 226 hens and 30 hens for the lowest number found. On the run 4a from Holm's farm the hens were roaming very far both in the willow plantation and the grassland, made up of groves. The subparts of the benchmarking analysis are dealing with the different parts of the run, form the pop-holes to the end of the plantation.

4.6.1 The area from the barn to the first trees

The first 13 meters away from the building over the run 4a are empty of tree and the soil is bare, sandy. This distance was highly variable form farm to farm: from 5 to 20 meters in between the pop-holes and the first trees according to the farm. The literature shows that more hens are ranging outside when there are diverse structures, especially in the first meters around the building (Nagle & Glatz, 2008).The nature of the surface over the first meters around the building influence the decision of the hens to go further or not, but also the decision of the farmer to plant the trees more or less far from the building (Hegelund et al. 2006). Nevertheless in the observations of this study the hens seem to cross a big distance of 20 meters without probes before they meet the first trees.

4.6.2 A source of food outside

On the farm 4 all the hens were feed outside two weeks after their arrival on the farm, when they were able to nest properly inside. This was made in order to educate them to go outside, according o the farmer. Although they will not be fed outside during the whole cycle of production, they should always find a source of food outside: field of mixed grain of sunflowers, corn and diverse grasses. The farmers who feed the hens outside, directly with grains or while seeding a fields of divers seeds, noticed that they do not have problem to get at least 50 % of the hens outside for the whole cycle. One of them also observed a preference from the hens for sunflower and corns (farm 7). This questions is crucial has the presence of a source of food outside strongly influence the hens for going outside or not (Zeltner and Hirt, 2003).

4.6.3 Do the pop-holes face the run?

On the run 4a there are pop-holes on two sides: west and east. The west side is facing a fenced after 9 meters and more hens were staying on the veranda on this side and very few hens were roaming on the outdoor area on the side of the run (figure 11). The east side is facing the plantation, the groves, the hedge and the grassland; fewer hens were staying on the veranda on this side and they could walk in a straight line to the end of the run. Over the seven farms there were cases when the pop-holes did not face the run but a fence after a few meters, for example on the run 1c (12 meters after the pop-holes). On this run the rare hens roaming further than 20 meters were walking along the fence, close to a firs forest belonging to another run. On the run 3c the first part of the orchard was very young and thus still protected with a fence. The hens had to go through a corridor to reach the oldest part of the orchard (elder trees) and just very few were actually reaching it. It seems that when the pop-holes face a fence after less than 15 meters

just a few hens are using the run. Furthermore a narrow and more than 15 meters long corridor tends to keep the hens back from the plantation area (Figures 12 & 13).

4.6.4 Management of the plantation

A plantation with a large amount of tree planted in rows and aiming to produce fruit or energy wood seem to be a specific feature for the outdoor area in Danish free range laying hens. Indeed the literature review did not really show any example of such a system in France. The run 4a included a willow plantation almost two years old with a density less than 1 meter between the rows. Comparing this plantation with the 25 other runs, no big impact was seen on the distribution: taking the age in account, the hens seems to roam until the same distance whatever the nature of the plantation (willows, poplars or orchard), the state of degradation of the grass giving a clue of the distance they can reach in average. But while asking the farmer about the management of the plantation, three main issues appeared:

Distance in between the rows: on the farm 6 the breeder told that 0.75 m in betweens the rows seems too dense for hens.

- The amount of light reaching the ground: at the end of the run 7a the soil was not very suitable for the willows and they could not grow very well; this let more light for the grass, which was then too high for the hens (figure 14).
- The accessibility for the hens: when the plantation is young the hens like to eat the young sprouts, which affect the production (lowest growth for the willows, the poplars and the firs, bad shape for the firs sold as Christmas trees).
- The breeder from the farm 7 told about the possibility to leave one row empty every 5 or 10 rows, in order to move a strip of grass and motivate the hens to go further in the plantation although the height of the grass in between the other row. The conventional cultivation systems with a distance in between the rows from 0.75 to 1.50 m do not allow the tractor to move in between. The figures 15 and 16 show how the orchard and its large strips are used.

A high density is good for the yield in case of production of biomass, or firs for Christmas trees. The disadvantage for the hens is that it easily becomes unmanageable, so that the fox has many hiding places, if he can enter the run. The hens also like to lay under the firs when the plantation is young and dense and the first branches very low.

To avoid the hens pecking the young sprouts it is possible to let one rows standing from the last cycle of production, for example every twenty rows, one row is not cut down. Then the hens will likely look for the shelter of this row and eat less sprouts of the young trees nearby, as noticed the breeder from the farm 7. It is also possible to protect some part of the run: it could be the youngest part of the plantation and the field which will produce corn, sunflower and grass grains later.

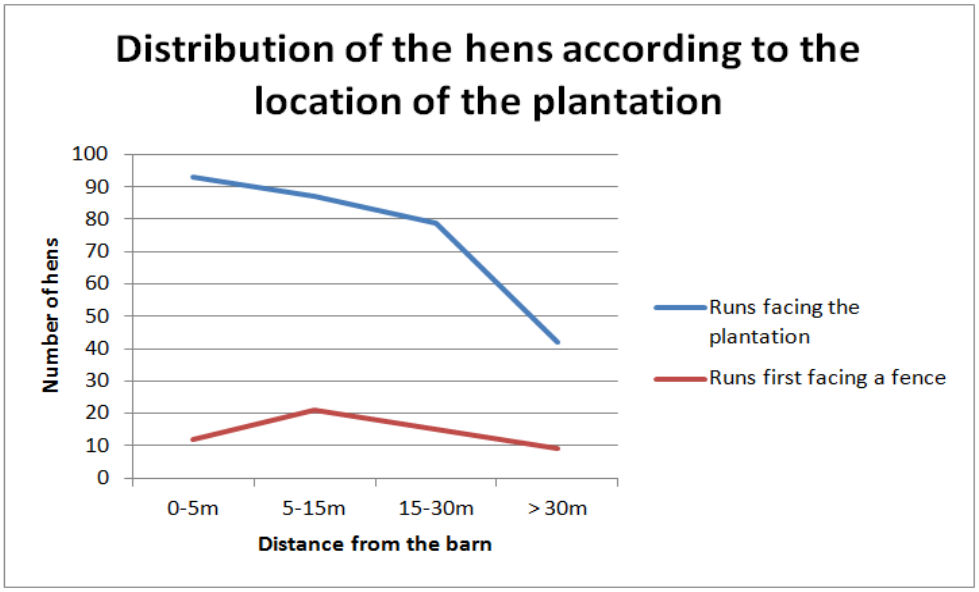
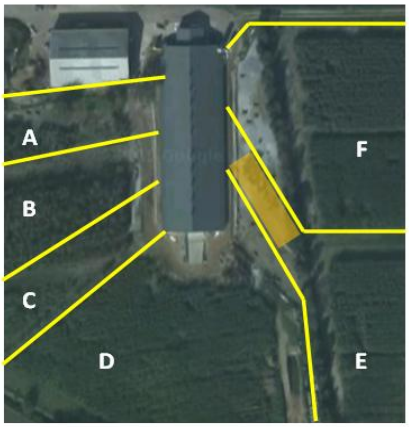


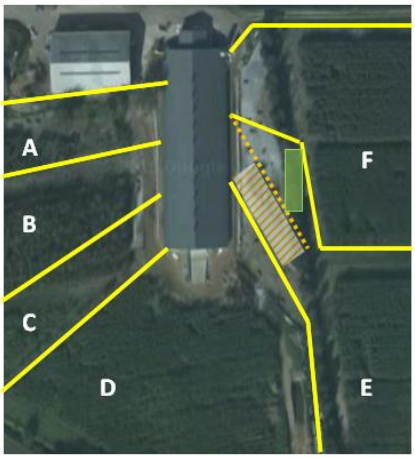
Fig. 11: Graph of the distribution observed on the 26 runs in front of the pop-holes and further.



Opposite: the building and the 100 meters surrounding. The six run are designed in a fan shape. They all have about the same area, which is not visible on this focused view. The pop-holes in the run E and D not facing the plantation and in the run E especially then hens have to walk over a long bare area before they can see the first trees (area in orange).

Above: the run E and the corridor from the pop-holes, corresponding with the orange area of the figure 4. Nevertheless the breeder tried to attract them with straw bale and young firs in the foreground. They like to eat the sprout.

Fig. 12: Do the pop-holes face the plantation?



Suggestion to avoid a corridor in the run E, as described above and now in orange on the figure. The rectangle in light green shows an additional part of the hedge which was in the run F before. It should play the role of a transition in between the bare area and the plantation, in addition to the groves and small isolated trees. Here the hedge is about 20 years old and 10 meters high.

The design on the run D did not change and the pop-holes are still facing a fence after a few meters. Nevertheless there is no corridor and thus much less possibility for congestion in the immediate area.

Fig. 13: Suggestion for the area not facing the pop-holes.

Top left-hand corner: willow with low density, 1.5 m. Yet it is not large enough to move between the rows. Moreover the trees are not very well developed because of a too wet soil. The grass is then too high for the hens and act as a barrier.

Top right-hand corner: here the trees are growing well and the area is very used by the hens. Furthermore the run was open since the beginning so they could eat the young shoots and that is why there are no branches at ground level.

Bottom left-hand corner: firs' plantation. The hens are roaming on the whole area and seem to appreciate the nettles. The trees are more than 15 years old and there are no branches anymore at ground level. Thus they do not try to lay, as it used to be the case when the plantation was younger.

Fig. 14: Different densities in the plantation.

Fig. 15: Orchard of Cherry trees, with poplars in the background. Hens like to perch.

Fig. 16: Orchard of Apple trees, with tractor width between rows. The degradation of the grass by the hens along the alley is fully visible. The hens seem to go a bit further under the trees.

5. Conclusion

Based and what was found in the literature review about the influence of the design of the run on the distribution, Danish specificities were observed on the 26 runs investigated. One of the most important features in the typology is the plantation. It could be a coppice for biomasse production, an orchard or sometimes a forest of firs for Christmas trees production. In most of case the first goal according to the farmer will be to bring a nice looking outdoor area for the hens and their welfare. As the area where the trees are planted is often quite large as the livestock is from 5,000 to 18,000 hens and this makes the area as a place for an additional production. The hens have an impact on the production of fruits while pecking the fruits but this is not seen as a problem by the farmers. When they have an access to the young plantations they like to eat the sprouts which can impact the growth of the willows and the final shape of the firs. Thus this can be seen as a way to attract the hens further in the run but sometime the breeder prefer to protect the young plantation at the early stage with a fence. This concept is also use to protect a field or cereals planted to produce grains which will later been eaten by the hens. Another way use by Danish farmer to make the run more attractive for the hens is to mow the grass when it is too high especially in the furthest part of the area. The benchmarking analysis made to figure out the features of the best run showed that the presence of groves with fruits in addition to a plantation of willow is a good combination. However when the trees are too narrow and look more like a forest the breeders noticed that it seems to be a good place for nesting. The distance of the first trees from the pop-holes does not really matter on the seven farms from the study although the literature shows that a too long distance can be a break to a further exploration by then hens. Actually the runs where the hens had to walk up to 20 meters to reach the first trees were the runs where the hens are roaming the furthest. The fact that the pop-holes are facing the plantation and the main part of the run seems to be a more important feature to motivate the hens to go outside the building.

Opportunities and further research

The livestock observed was entering the runs for the first time at 18 weeks in all cases and all the chicks come from a free range breeding system with agroforestry. But the density in this breeding is quite high and it would be interesting to know how behave the hens when they are less than 1,000 per flock.

Bibliography

Azzurra Annunziata & Riccardo Vecchio, 2014. Italian consumer awareness of layer hens' welfare standards: a cluster analysis. International Journal of Consumer Studies 36, 647-655.

Béral, C., 2013. CasDAR Parcours de volailles. Comment valoriser les services agroécologiques des parcours ? Chambres d'Agriculture 1025, 6-7.

Béral, C., Guillet, P. & Brun, V., 2014. Aménagements arborés des parcours de volailles. Guide Technique. Ministère de l'Agriculture, de l'Agro-Alimentaire et de la Forêt.

Bestman, M., 2014. Initial Stakeholder Meeting Report Agroforestry for poultry systems in the Netherlands. Agforward, Brussels.

Bestman, M., Stoffelsma, M., Verwer, C. & van Eekeren, N., 2003. 2nd European Agroforestry Conference. European Union, Brussels.

Bestman, M. et al., 2013. Introducing trees in Dutch dairy and poultry farms. Experiences dairy and poultry farmers' networks in The Netherlands. Nordic Association of Agricultural Scientists, NJF Report 3(9), 155-156.

Bestman, M. & Wagenaar, J., 2003. Farm level factors associated with feather pecking in organiclaying hens. Livestock Production Science 80, 133-140.

Bracke, M. B. M. & Hopster, H., 2006. Assessing the importance of natural behavior for animal welfare. Journal of Agricultural and Environmental Ethics 19, 77-89.

Brownlow, M. C., 1994. The Characteristics and Viability of Land-Use Systems Which Integrate Pig or Poultry Production with Forestry in the UK. Reading: University of Reading, MA.

Burner, D., Campbell, L. & Meier, S., 2014. Silvopasture Add Value to Christmas Tree Plantation. http://www.aftaweb.org/latest-newsletter/temporate-agroforester/55-2003-vol-11/july-no-3/31-christmas-tree-plantation.html (retrieved July 2014).

Candland, D. K., Nagy, M. Z. & Conklyn, D. H., 2003. Emotional behavior in the domestic chicken (white leghorn) as a function of age and developmental environment. Journal of Comparative and Physiological Psychology 58(6) 1009-1073.

Cayez, C., 2014. Influence des caractéristiques des parcours « plein air » sur el comportement exploratoire des volailles. Institut Supérieur d'Agriculture, Lille.

Chow, A. & Hogan, J. A., 2005. The development of feather pecking in Burmese red junglefowl: the influence of early experience with exploratory-rich environments. Applied Animal Behaviour Science 93, 283-294.

Chu, B. et al., 2010. Veterinary antibiotic sorption to agroforestry buffer, grass buffer and cropland soils. Agroforestry Systems 1(79), 67-80.

Coton, J., 2013. How do layers use the outdoor range in Danish organic egg production? Aarhus University, Aarhus.

Danish Poultry Council Annual Report, 2000. http://www.agricultureandfood.dk (retrieved May 2015)

Dawkins, M. S., 2003. Behaviour as a tool in the assessment of animal welfare. Journal of Zoology 106, 383-387.

Dawkins, M. S., 2003. Behaviour as a tool in the assessment of animal welfare. Zoology, Urban & Fisher Verlag 106, 383-387.

Dawkins, M. S., 2006. A user's guide to animal welfare. Trends in Ecology and Evolution 21(2), 27-38.

Dawkins, M. S., 2006. Chickens, Trees and Farmers - an Experiment in Mutual Benefit. http://www.thepoultrysite.com/articles/550/chickens-trees-and-farmers-an-experiment-in-mutual-benefit (Retrieved May 2015).

Dawkins, M. S., 2006. Through animal eyes: What behaviour tells us. Applied Animal Behaviour Science, 100, 4-10.

Dawkins, M. S. et al., 2003. What makes free-range broiler chickens range? In situ measurement of habitat preference. Animal Behaviour 66, 151-160.

Dekker, S. E. M., Aarnink, A. J. A., de Boer, I. J. M. & Groot Koerkamp, P. W. G., 2011. Emissions of ammonia, nitrous oxide, and methane from aviaries with organic laying hen husbandry. Biosystems Engineering 110, 123-133.

Dupraz, C. & Neuwman, S. M., 1997. Temperate Agroforestry: The European Way, in: Gordon, A.M., Neuwman, S.M. (Eds.), Temperate Agroforestry Systems, Wallingford, United Kindom, pp. 181-236.

Eichhorn, M. P. et al., 2006. Silvoarable systems in Europe—past, present and future prospects. Agroforestry Systems 67, 29-50.

Febrer, K., Jones, T., Donnelly, C. & Dawkins, M. S., 2006. Forced to crowd or choosing to cluster? Spatial distribution indicates social attraction in broiler chickens. Animal Behaviour 72, 1291-1300.

Gebhardt-Henrich, S. G., Toscano, M. J. & Fröhlich, E. K. F., 2014. Use of outdoor ranges by laying hens in different sized flocks. Applied Animal Behaviour Science 155, 74-81.

Gilani, A. M., Knowles, T. G. & Nicol, C. J., 2014. Factors affecting ranging behaviour in young and adult laying hens. British Poultry Science 55(2), 127-135.

Grigor, P. N., Hughes, B. O. & Appleby, M. C., 2001. Effects of regular handling and exposure to an outside area on subsequent fearfulness and dispersal in domestic hens. Applied Animal Behaviour Science 44, 47-55.

Grigor, P. N., Hughes, B. O. & Appleby, M. C., 2001. Emergence and dispersal behaviour in domestic hens: effects of social rank and novelty of an outdoor area. Applied Animal Science 45, 97-108.

Hegelund, L. & Sørensen, J. T., 2007. Measuring fearfulness of hens in commercial organic egg production. Animal Welfare 16, 169-171.

Hegelund, L., Sorensen, J. T. & Hermansen, J. E., 2006. Welfare and productivity of laying hens in commercial organic egg production systems in Denmark. New Journal of Agricultural Science 54(2), 147-155.

Hegelund, L., Sørensen, J. T., Kjaer, J. B. & Kristensen, I. S., 2005. Use of the range area in organic egg production systems: effect of climatic factors, flock size and artificial cover. British Poultry Science 46(1), 1-8.

Heng Yan, Hanawa Peterson Hikaru and Li Xianghong, 2013. Consumer Attitudes toward Farm-Animal Welfare: The Case of Laying Hens. Journal of Agricultural and Resource Economics 38(3), 418–434.

Hermansen, J. E. et al., 2005. Forbedrede udearealer i økologisk ægproduktion, Tjele: Danmarks JordbrugsForskning.

Huber-Eicher, B. & Wechsler, B., 2001. Feather pecking in domestic chicks: its relation to dustbathing and foraging. Animal Behaviour 54, 757-768.

Johansen, N. F., 2012. Pil og poppel (Lavskov) i hønsegårde. Uddrag fra Dansk Erhvervsfjerkrae, pp. 280-282.

Johnsen, P. F., Vestergaard, K. S. & Nørgaard-Nielsen, G., 1998. Influence of early rearing conditions on the development of feather pecking and cannibalism in domestic fowl. Applied Animal Behaviour Science 60, 25-41.

Jones, T. et al., 2006. Welfare and environmental benefits of integrating commercially viable free-range broiler chickens into newly planted woodland: A UK case study. Agricultural Systems Article in Press, 123-178.

Jose, S., 2009. Agroforestry for ecosystem services and environmental benefits: An overview. Agroforestry Systems 76, 1-10.

Jose, S., Gillespie, A. R. & Pallardy, S. G., 2004. Interspecific interactions in temperate agroforestry. Agroforestry Systems 61, 237-255.

Kemp, P. D., Mackay, A. D., Matheson, L. A. & Timmins, M. E., 2001. The forage value of poplars and willows. Proceedings of the New Zealand Grassland Association 63, 155-119.

Kjaer, J. B. & Sørensen, P., 2002. Feather pecking and cannibalism in free-range laying hens as affected by genotype, dietary level of methionine + cystine, light intensity during rearing and age at first access to the range area. Applied Animal Behaviour Science 76, 21-39.

Kjaer, J. B. & Vestergaard, K. S., 1999. Development of feather pecking in relation to light intensity. Applied Animal Behaviour Science 62, 243-254.

Knierim, U., 2006. Animal welfare aspects of outdoor runs for laying hens: a review. New Journal of Agricultural Sciences 54-2, 34-41.

Kongsted, A. G., 2014. Initial Stakeholder Meeting Report Agroforestry for organic poultry and pig production in Denmark.

Le Douarin, P., Germain, K., Puybasset, A. & Guillet, P., 2012. Les bienfaits du parcours aménagé. Réussir Avi 77, 12-21.

Leroyer, J. & Lubac, S., 2009. Produire du poulet de chair en AB, Paris: Institut Technique de l'Agriculture Biologique.

Lindhard Pedersen, H. et al., 2004. Combined production of broilers and fruits. http://orgprints.org/14522 (retrieved May 2015).

Lubac, S., 2006. Impacts d'aménagements de la zone frontale des parcours en élevages de poules pondeuses en Rhône Alpes. Sciences et Techniques Avicoles 53, 14-22.

Lubac, S., 2008. La gestion des parcours en poules et poulets BIO. Institut Technique des Sciences Avicoles.

Markussen, C. & Johansen, N. F., 2014. Bedre udnyttelse af ressourcernei økologisk ægproduktion Indretning og drift af hønsegårde, Katalog. Nordisk Miljømaerkning.

Markussen, P. & Petersen, P., 2013. Beplantning i økologiske hønsegårde. Nordisk Miljømaerkning.

Mason, G., Clubb, R., Latham, N. & Vickery, S., 2007. Why and how should we use environmental enrichment to tackle stereotypic behaviour? Applied Animal Behaviour Science 102, 163-188.

McAdam, J. et al., 2008. In Agroforestry in Europe: Current Status and Future Prospects. Springer, Belfast, 157 p.

Mosquera-Losada, M. et al., 2012. Book of Abstracts. What priorities for European agroforestry? European Commission.

Nagle, T. & Glatz, P. C., 2008. Free range hens use the range more when the outdoor environment is enriched. Asian - Australasian Journal of Animal Sciences 25(4).

Newmann, S. & Gordon, A., 1997. Temperate agroforestry systems. CAB International.

Nicol, C. J., Pötzsch, C., Lewis, K. & Green, L. E., 2003. Matched concurrent case-control study of risk factors for feather pecking in hens on free-range commercial farms in the UK. British Poultry Science 44(4), 515-523.

Patterson, P. et al., 2008. Vegetative buffers for fan emissions from poultry farms. Journal of Environmental Science and Health 43, 199-204.

Pedersen, L. H. et al., 2005. Combined production of broilers and fruits. Organic e-print.

Rigueiro-Rodriguez, A., Mosquera-Losada, M. R. & Mc Adam, J., 2009. Agroforestry in Europe, Current Status and Future Prospects. Springer.

Ringgenberg, N. et al., 2014. Does nest size matter to laying hens? Applied Animal Behaviour Science 155, 66-73.

Rivera-Ferre, M. G., Lantinga, E. A. & Kwakkel, R. P., 2007. Herbage intake and use of outdoor area by organic broilers: effects of vegetation type and shelter addition. New Journal of Agricultural Sciences, pp. 279-291.

Roinsard, A., Guillet, P. & Pineau, C., 2014. Typologie d'aménagements agroforestiers sur les parcours volailles de chair Label Rouge et Biologiques. CASDAR Parcours Volailles.

Schütz, K. E. & Jensen, P., 2001. Effects of Resource Allocation on Behavioural Strategies: A Comparison of Red Junglefowl (Gallus gallus) and Two Domesticated Breeds of Poultry. Ethology 107,753-765.

Sinclair, F. L., Eason, W. R. & Hooker, J., 2000. Understanding and management of interactions, agroforestry in the UK. Forestry Commission.

Smith, J., 2014. Initial Stakeholder Meeting Report: Woodland Eggs in the UK.

Smith, J. & Bauer, C., 2014. Can the range contribute to the nutritional needs of organic pigs and poultry? ICOPP Report (Improved Contribution of Local Feed to Support 100% Organic Feed Supply to Pigs and Poultry).

Smith, J., Pearce, B. D. & Wolfe, M. S., 2012. A European perspective for developing modern multifunctional agroforestry systems for sustainable intensification. Renewable Agriculture and Food Systems 27 (4), 323-332.

Smith, J., Pearce, B. D. & Wolfe, M. S., 2012. Reconciling productivity with protection of the environment: Is temperate agroforestry the answer? Renewable Agricultural and Food Systems 28 (1), 80-92.

Suarez, S. D. & Gallup, G. G., 2006. Open-field behavior in chickens: the experimenter is a predator. Journal of Comparative and Physiological Psychology 3 (96), 432-439.

The-Woodland-Trust, 2014. A Woodland Trust guide to tree planting for free range poultry. The Woodland Trust.

Tyndall, J. & Colletti, J., 2011. Mitigating swine odour with strategically designed shelterbelt systems: A review.. Agroforestry Systems 69, 45-65.

Uitdehaag, K. A. et al., 2009. Mixed housing of different genetic lines of laying hens negatively affects feather pecking and fear related behaviour. Applied Animal Behaviour Science 116, 58-66.

Vestergaard, K. & Hogan, J. A., 1999. The development of a behavior system: dustbathing in the burmese red junglefowl. Iii.effects of experience on stimulus preference. Behaviour 3 (121), 215-230.

Vestergaard, K. S., Kruijt, J. P. & Hogan, J. A., 1993. Feather pecking and chronic fear in groups of red junglefowl: their relations to dustbathing, rearing environment and social status. Applied Animal Behaviour Science 45, 1127-1140.

Volk, T. A. et al., 2006. The development of short-rotation willow in the northeastern United States for bioenergy and bioproducts, agroforestry and phytoremediation. Biomass and Bioenergy 30, 715-727.

Workman, S. W., Allen, S. C. & Demers, C., 2014. The Practice and Potential of Agroforestry in the Southern United States, Florida: University of Florida. (PhD Thesis)

Yates, C., Dorward, P., Hemery, G. & Cook, P., 2007. The economic viability and potential of a novel poultry agroforestry system. Agroforestry System 69, 13-28.

Zeltner, E. & Hirt, H., 2003. Effect of artificial structuring on the use of laying hen runs in a free-range system. British Poultry Science 4 (44), 533-537.

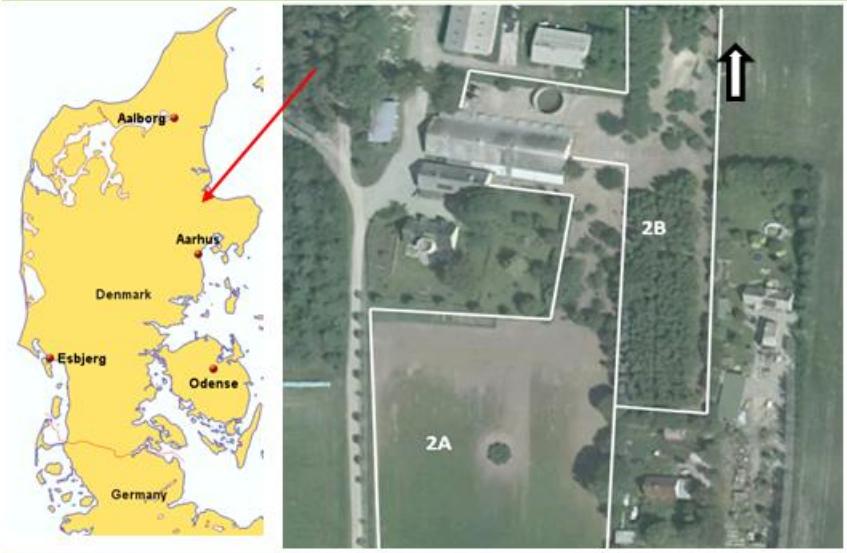
Zeltner, E. & Hirt, H., 2008. Factors involved in the improvement of the use of hen runs. Applied Animal Behaviour Science 114, 395-408.

Zeltner, E. & Hirt, H., 2012. Optimising the use of hen runs by structures. Swiss Research Institut of Organic Farming.

Zeltner, E., Hirt, H. & Hauser, J., 2011. How to motivate laying hens to use the hen run? Swiss Research Institut of Organic Agriculture.

Appendix n°1: Descriptive sheet n°2

2. Kaj Jørgensen, visit on the 29th of May in Allingåbro, 2 runs, 4,500 hens, Hisex White, 46 weeks old



Management: This breeder planted the first firs in 1995 and the first apple trees in 1997. The first thought he had in mind was to sell the firs as Christmas trees, but a he noticed that the hens like to peck the young sprouts and the Christmas trees are known to be a good place for nesting. Both of those reasons lead poultry breeders to give up the apple production. Nowadays he designs the run to get a nice looking and diversified forest, attractive for the look.

Trees: Birch, Blackthorn, Cherry, Apple, Dogwood (*Cornus sanguine),* Hazel, Maple field, Oak, Willow, Yew, Chestnut, Plum, Sycamore, Walnut, Elder, Fir, Pear.

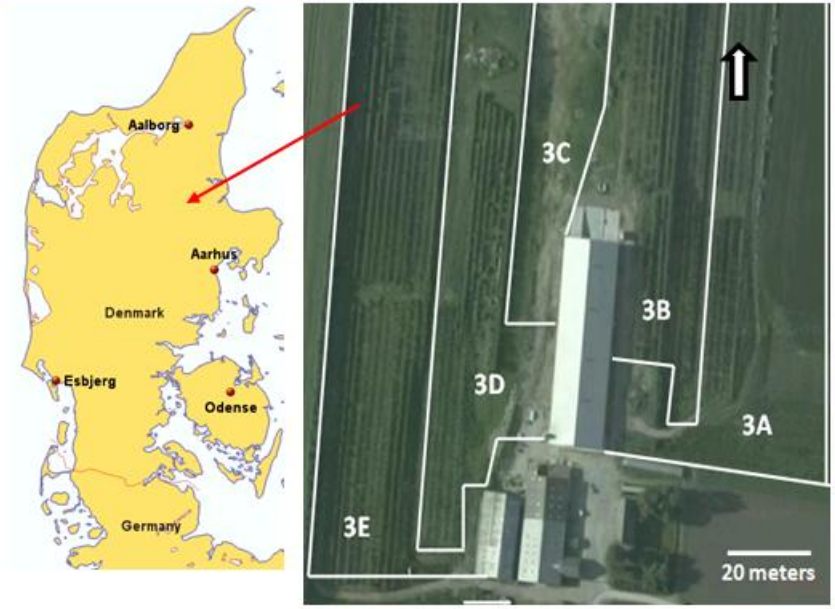
Scan sampling analysis: Those two flocks are different from all the others farms because of the number of animals: only 4,500 hens in total thus 2,250 per flock. An average of 135 hens in the 5-15 meters area was observed with a bad weather, which is quite a good score in comparison with the other farms.

Fig. 1: Location of the run with an aerial view and main information recorded on field

Fig. 2: General design with the types of each run

Appendix n°2: Descriptive sheet n°3

3. Svend Erik Rasmussen, visit on the 4th of June in Randers, 5 runs, 13,500 hens, Hisex White 50 weeks old, Hisex White + Brown, 30 weeks old



Management: The orchard began about 10 years ago, because the breeder wanted a nicer run for the hens. He would like the hens to go further in the run because he noticed moles hills damages in the far area and he thinks that while pecking the ground and taking worms, the hens are actually chasing the moles.

Trees: Cherry, Apple and Pear Trees, Elder, Mirabelle. Varieties: Holstein Cox, Rubinstein, Aristo, Rod Aroma, Altimene, Mirabelle, Rod Tupar

Scan sampling analysis: The run C is a newly planted orchard and therefore the hens still could not enter it. There access was limited to a bare area. They were really just a few roaming outside. In the orchard with cherries, run A and B, many hens were perching.

Fig. 1: Location of the run with an aerial view and main information recorded on field

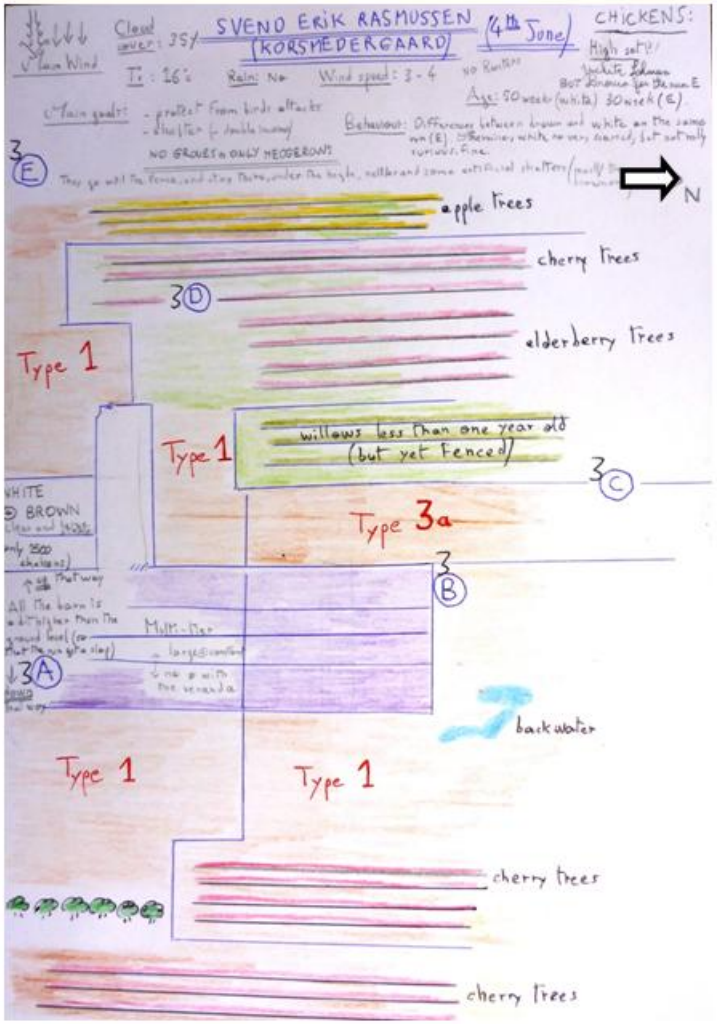


Fig. 2: General design with the types of each run

Appendix n°3 : Descriptive sheet n°6

6. Fleming Haugaard, visit on the 9th of June in Sønderjylland, 6 runs, 18,000 hens, Hisex White, 25 weeks old

Fig. 1: Location of the run with an aerial view and main information recorded

Management: The farmer cut the grass strips around the run because it noticed that the hens like it more. He planted trees to get more hens outside. At first it has been very time consuming to move the grass and to weed, and still by now the first fruits trees, 20 meters away from the pop-holes, seem to have a hard time.

Trees: Ash, Oak, Alder, Wild Cherry, Hazel, Hawthorn, Bird Cherry, Dogwood, Poplar, Apple Tree, Blackthorn, Snowberry, Lilac, Sitka Spruce, Cypress and White willow

Scan sampling analysis: pop-holes. On every run the area in between the pop-holes and the first trees is quite long wit and average of 16 meters. In this area some hens are perching and walking around the straw bales 5 meters far from the pop-holes.

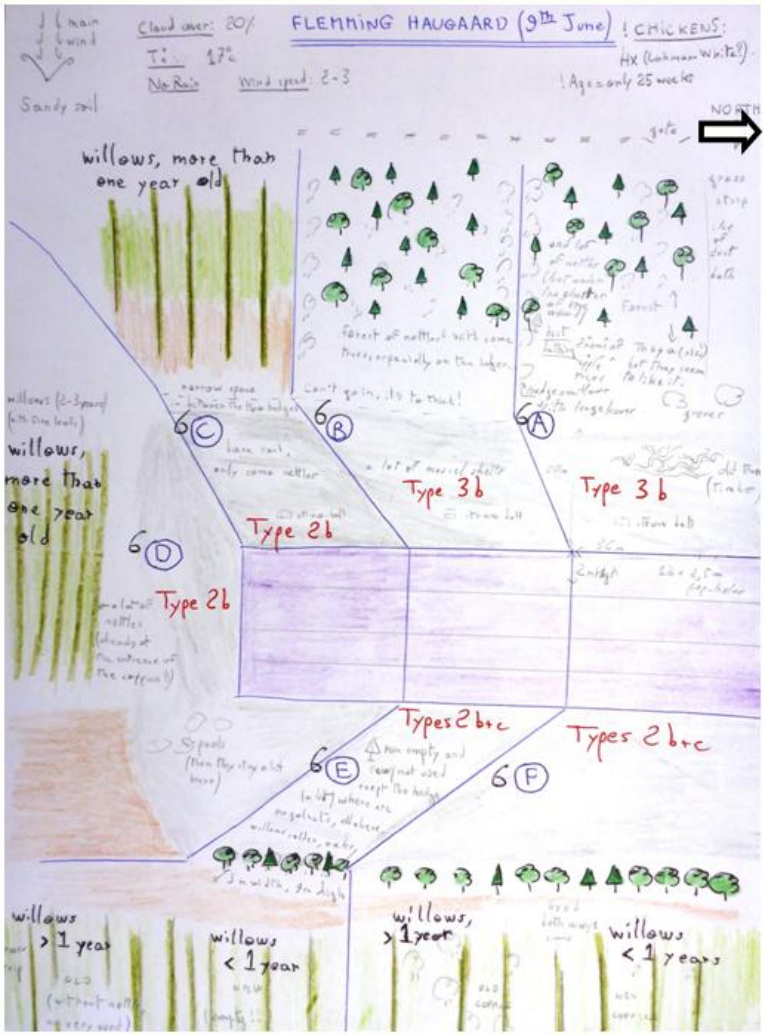


Fig. 2: General design with the types of each run

Appendix n°4 : Descriptive sheet n°7

7. Karin Petersen, visit on the 11th of June in Bylderup-Bov, 4 runs, 12,000 hens, Klavo Loehr Petersen, 36 weeks old

Management: Although the willow plantation is not dense, they cannot mow in between the rows and the hens are not using the plantation when the grass is too high. They also seed a various mixture of seeds from 30 to 60 meters far from the building. According to them the fact that the hens find a wide variety of grains outside is the most important factor to get them outside.

Trees: Birch, Blackthorn, Cherry, Apple, Dogwood (Cornus sanguine), Hazel, Maple field, Oak, White willow, Yew, Plum, Sycamore, Walnut, Alder, White Poplar, Elder, Thuja, Fir, Ash tree, Alder, Pear tree. *Grass for the seeded area:* Herbs, Sunflowers, Wheat, Cumin, Chicory, Red and White Clover, Plantain, Yarrow, Sainfoin, Faba Beans, Burnet, Trefoil, Lucerne, Sorghum.

Scan sampling analysis: On the run B more than 300 hens stayed under the shade of a very long hedge of 100 m. long, situated at the corner of the building. According to the breeder the orchard is more used than the willow plantation because she can move the grass in between the rows of fruit trees.

Fig. 1: Location of the run with an aerial view and main information recorded

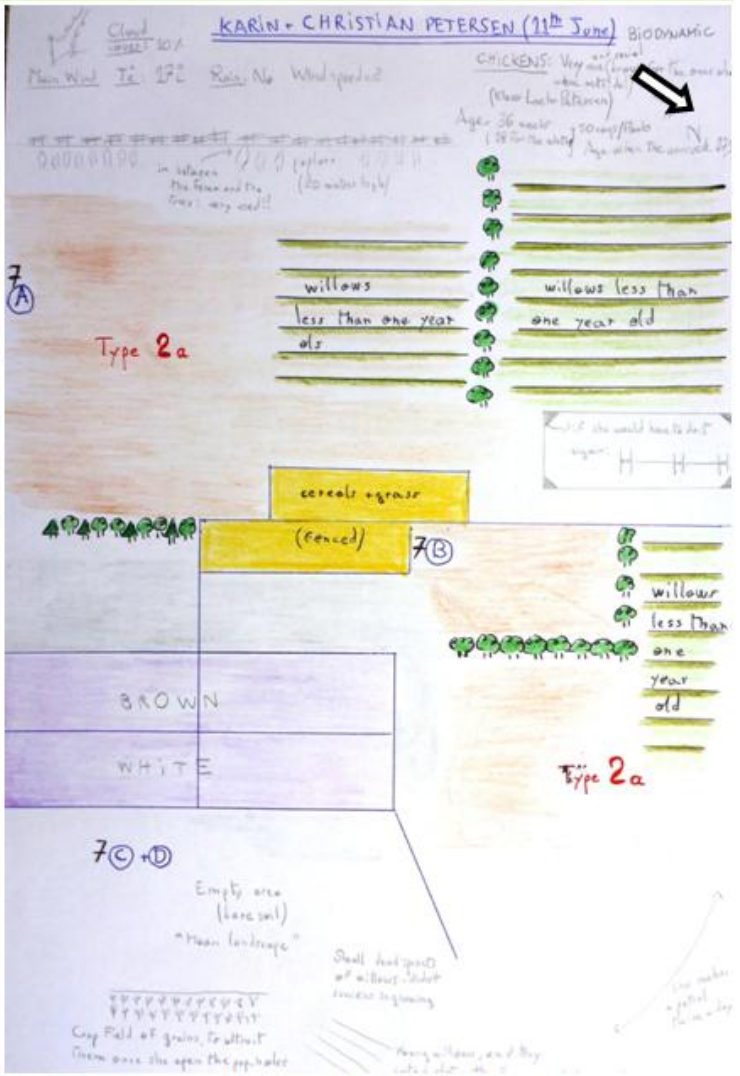


Fig. 2: General design with the types of each run

Appendix n°5: Scan samplings for the distribution and the size of the density

Breeder	Run	Source of grains outside?	*Average number of hens per zone along the day*					*% of hens outside*
			0-5m	5-15m	15-30m	> 30m	Total	
Jan Volmar	1a	No	160	120	100	85	465	15,5
	1b		75	25	20	15	135	4,5
	1c		65	55	15	7	142	4,7
	1d		100	140	80	15	335	11,2
Kaj Jørgensen	2a	No	110	50	110	60	330	11,0
	2b		75	135	110	50	370	12,3
Svend Erik Rasmussen	3a	No	81	95	70	101	347	11,6
	3b		95	95	70	95	355	11,8
	3c		15	7	8	0	30	1,0
	3d		15	10	15	70	110	3,7
	3e		51	48	50	80	229	7,6
Ingeborg Holm	4a	Yes	81	3	300	500	884	29,5
	4b		20	28	62	42	152	5,1
	4c		25	27	58	38	148	4,9
Jette + Bent Jørgensen	5a	No	7	16	31	58	323	10,8
	5b		10	15	3	27	595	19,8
	5c		8	17	33	30	112	3,7
	5d		7	16	30	38	55	1,8
Fleming Haugaard	6a	No	20	5	23	48	88	2,9
	6b		20	6	27	53	91	3,0
	6c		2	3	45	70	96	3,2
	6d		10	7	5	72	106	3,5
	6e		11	7	5	46	120	4,0
	6f		24	28	29	58	94	3,1
Karin Petersen	7a	Yes	90	100	88	45	69	2,3
	7b		98	95	102	300	139	4,6

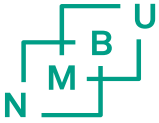
Breeder and place of the visit	Average size of the building per flock	Average density (hens/m²) per flock
Jan Volmar	632 m²	4,7
Kaj Jørgensen	373 m²	6,1
Svend Erik Rasmussen	640 m²	4,7
Ingeborg Holm	Run A = 937 m² Run B and C = 650 m²	A = 3,2 B and C = 4,6
Jette + Bent Jørgensen	549 m²	5,2
Fleming Haugaard	483 m²	6,2
Karin Petersen	420 m²	7

Appendix n°6: Distribution of the different type of plantation

Appendix n°7: Difference of density in the veranda

Figure 1: small pop-holes, low veranda and no large door open; Hisex White, 46 weeks old

Figure 2: high and large veranda, a large door is full open at the end; Lohman Brown, 43 weeks old



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