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Animal welfare in organic poultry production

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Abstract

Outdoor access, reduced stocking densities, natural light, no beak trimming, and 'slow-growing' broilers provided with raised sitting areas, are some of the main features of organic poultry production intended to improve bird welfare. On-farm studies are important to increase our knowledge of animal welfare in commercial production. In this thesis, on-farm studies were performed on eight organic broiler farms and 11 organic laying hen farms in Sweden, to assess the present animal welfare situation in terms of housing, bird health and behaviour, and free-ranging. The findings were assessed in relation to different animal welfare definitions and relevant organic standards. The results show that important welfare issues, such as severe feather pecking in laying hens and gait impairment in broilers, can be found in organic poultry production. Outdoor areas generally offered limited protection in the form of vegetation and/or artificial shelters, and most birds remained close to the house when ranging. The broilers were motivated as well as physically capable of perching, but the available space on raised sitting areas was limited. Behavioural observations indicated that the laying hens and broilers were fearful of humans. The emphasis on providing opportunities to perform natural behaviours in organic production may improve bird welfare by promoting pleasant, rather than merely avoiding unpleasant, experiences. However, in order to influence poultry welfare in practice and not only in theory, the content of organic standards must transfer all the way to commercial farms. This can to a certain extent be managed by the individual farmer, but other undertakings might be obstructed by aspects contained within the structure of modern poultry production.

Keywords: laying hen, broiler chicken, slow-growing, health, natural behaviour, positive welfare, free-ranging, environmental enrichment, flock size

Good enough? Djurvälfärd i ekologisk fjäderfäproduktion

Sammanfattning

Ekologisk fjäderfäproduktion innebär bland annat krav på utevistelse, lägre beläggningsgrad, naturligt ljus, och långsamväxande slaktkycklingraser med tillgång till upphöjda sittplatser, samt förbud mot näbbtrimning, för att förbättra djurens välfärd. För att öka kunskapen om lantbruksdjurens välfärd i kommersiell produktion är vetenskapliga studier som genomförs ute på gårdar viktiga. Denna avhandling baseras på två studier från åtta svenska ekologiska slaktkycklinggårdar respektive 11 ekologiska värphönsgårdar. Syftet var att undersöka djurvälfärden avseende inhysning, djurhälsa och beteende, samt utevistelse. Fynden diskuteras här mot bakgrund av olika definitioner av djurvälfärd och relevanta ekologiska regelverk. Resultaten visar att viktiga välfärdsproblem, så som till exempel fjäderplockning hos värphöns och hälta hos slaktkycklingar, förekommer i ekologisk produktion. Rasthagarna erbjöd överlag begränsat med skydd i form av växtlighet och/eller artificiella strukturer, och utomhus vistades de flesta hönsen och kycklingarna i närheten av stallet. Slaktkycklingarna var både motiverade samt fysiskt kapabla till att använda de upphöjda sittytorna, men tillgången på dessa var dock begränsad. Beteendeobservationer indikerade en rädsla för människor hos värphönsen såväl som hos slaktkycklingarna. En viktig aspekt inom den ekologiska animalieproduktionen är ökade möjligheter att utföra naturliga beteenden, som kan förbättra djurens välfärd genom att främja positiva, snarare än att enbart förhindra negativa, upplevelser. För att förbättra djurvälfärden i praktiken, och inte enbart i teorin, krävs dock att de ekologiska regelverken når hela vägen till gårdsnivå. Den individuella lantbrukaren kan påverka vissa aspekter, dock inte alla, eftersom en del snarare beror på faktorer inom strukturen för modern kommersiell fjäderfäproduktion.

Nyckelord: värphöns, slaktkyckling, långsamväxande, hälsa, naturligt beteende, positiv välfärd, frigående, utevistelse, miljöberikning, flockstorlek

Dedication

To mum. Because you were right, of course.

Contents

List of publications

This thesis is based on the work contained in the following papers, referred to by Roman numerals in the text:

I. Göransson, L., Yngvesson, J. & Gunnarsson, S. (2020). Bird health, housing and management routines on Swedish organic broiler chicken farms. Animals, 10 (11), 2098

II. Göransson, L., Gunnarsson, S., Wallenbeck, A. & Yngvesson, J. (2021). Behaviour in slower-growing broilers and free-range access on organic farms in Sweden. Animals, 11 (10), 2967

III. Göransson, L., Yngvesson, J. Abeyesinghe, S.M., & Gunnarsson, S. How are they really doing? Animal welfare in terms of health and behaviour on organic laying hen farms (manuscript)

IV. Göransson, L., Abeyesinghe, S.M., Gunnarsson, S. & Yngvesson, J. Easier said than done! Organic farmers consider free-ranging important for laying hen welfare, but outdoor areas need more shelter – lessons from research and practice (manuscript)

Papers I-II are reproduced with the permission of the publishers.

The contribution of Lina Göransson to the papers included in this thesis was as follows:

I. Conceptualisation, methodology, investigation, data curation and formal analysis, writing (original draft, reviewing and editing)

II. Conceptualisation, methodology, investigation, data curation, writing (original draft, reviewing and editing)

III. Conceptualisation, methodology, investigation, data curation and formal analysis, writing (original draft, reviewing and editing)

IV. Conceptualisation, methodology, investigation, data curation, writing (original draft, reviewing and editing)

1. Introduction

The two studies on which this thesis is based were conducted as part of the European project FreeBirds, of which the general aim was to generate knowledge and investigate ways of improving management of free-range systems in organic poultry production. Data collection performed in Sweden was part of a project work package evaluating the suitability of different poultry hybrids for organic farming. Data collection on broiler farms was part also of a project funded by SLU Ekoforsk. The overall aim of the latter was to map commercial organic broiler production in Sweden.

Two slower-growing broiler hybrids became commercially available in Sweden in 2014 and 2016, respectively, and as a consequence the number of organic broiler farms increased rapidly between 2015 and 2017 (Swedish Board of Agriculture 2022a). Organic broiler production in Sweden was thus rather recent at the time of data collection (2018) and knowledge of bird welfare on these farms was limited. The first organic laying hen farm in Sweden appeared in 1995, and there are at present around 1.2 million laying hens on just under 100 farms in Sweden (Swedish Board of Agriculture 2022a). Prior to this thesis, the latest epidemiological study including organic egg production in Sweden was performed almost 10 years ago (Jung *et al.* 2020).

On-farm studies are imperative in order to gain knowledge about the welfare of animals in a commercial production context (Dawkins 2012). Such research allows for welfare to be assessed under conditions as they are on farms – where there is a complex interaction between influencing factors and where other aspects than welfare, such as cost of production, feasibility, and environmental concerns, must be taken into account. On-farm studies thus provide important information about what works and does not work in practice, which makes the results highly relevant for achieving welfare improvements on a farm level (Dawkins 2012).

2. Background

There is at present no bird species more abundant in the world than the domestic chicken (*Gallus gallus domesticus*) (Bird Spot 2022). With a standing global population of 33 billion animals, it by far exceeds that of any other domestic or wild bird species, or any other terrestrial farm animal (FAOSTAT 2022). Chicken meat and egg production have increased markedly in recent decades, to represent a larger fraction of global animal protein consumption (FAOSTAT 2022). Nearly 71 billion chickens were slaughtered for meat worldwide in 2020, and almost 8 billion laying hens produced a total of 87 million tonnes of eggs (FAOSTAT 2022). These figures represent an almost incomprehensible number of individual animals in human care, for whose welfare we are responsible.

2.1.1 From the jungle to commercial production

It began with the dinosaurs. Although birds as we know them today may not look much like it, they may in fact be considered 'small dinosaurs' (Field *et al.* 2020). One such small dinosaur – the red jungle fowl (*Gallus gallus*) – can be found in the jungle of South and South East Asia. It was here that domestication of the aforementioned fowl took place more than 8000 years ago, during the Neolithic (also known as the First Agricultural) Revolution (West & Zhou 1988; Wang *et al.* 2020). Today, the domestic chicken can be found worldwide, as a direct consequence of movement of people across the globe. Its arrival in Europe probably occurred around 3000 years ago (Perry-Gal *et al.* 2015).

Although sport, *i.e.* cock fighting, was a primary reason for domestication, chickens were also important for aesthetic and religious purposes (Wood-Gush 1959). However, the greatly intertwined history of chickens and humans obviously depend strongly on the important food source that chickens have come to represent for humans. Historical evidence suggests that specialised poultry farming emerged already during Roman times, but that this form of agriculture was discontinued with the fall of the Roman Empire (Wood-Gush 1959). It was not until much later, during the Industrial Revolution, that the chicken once more became important as an agricultural animal (Wood-Gush 1959).

Early poultry production at the end of the 19th Century consisted of small backyard flocks (Appleby *et al.* 2004). Each individual chicken would provide eggs throughout her life, as well as meat at the end of it. Agricultural systems had developed according to the local climate and landscape, and different animal breeds adapted to the context had emerged as a reflection of this (Baars *et al.* 2004). By the turn of the 19th Century, poultry farming became an expanding livestock enterprise. Human understanding and control over different aspects of production increased, involving *e.g.* artificial incubators, improved hygiene measures, use of vaccines and antibiotics, photoperiodic manipulation and better knowledge of nutritional requirements. Instead of scavenging for food around the house, large flocks were provided with a balanced, complete diet while housed in a controlled indoor environment (Appleby *et al.* 2004). Selective breeding for production traits intensified and resulted in two distinct and highly specialised types of birds used for egg and meat production (laying hens and broilers, respectively). This, in combination with the aforementioned profound changes in management and housing, allowed for the rapid development and intensification of poultry production to continue throughout the 20th Century (Appleby *et al.* 2004).

2.1.2 Different, but same same

The natural habitat of the red jungle fowl includes areas of relatively dense vegetation, with shrubs and trees that offer protection against predators. The coloration of their plumage largely matches the environment, making them difficult to detect (Collias & Collias 1967). They live in small, stable social groups consisting of one dominant male and several females and spend their days within their home range, which is limited to a few hectares (Collias & Collias 1967). In the group there is an established dominance hierarchy, *i.e.* a pecking order (Collias *et al.* 1966). Red jungle fowl show a diurnal rhythm and approaching dusk they return to a roosting tree, where they spend the night on a branch, safe from ground predators. The roosting tree is left before dawn (Collias & Collias 1967). Adult red jungle fowl spend around 60% of their waking hours foraging, which includes a considerable amount of exploratory scratching and pecking at the ground, as well as feeding on *e.g.* fruits, seeds and insects (Dawkins 1989). During the course of the day, they may return to the roosting tree to rest and engage in plumage maintenance behaviour, such as preening and dust bathing (Appleby *et al.* 2004).

Domestication, the process whereby animal populations are adapted to life with humans through genetic and phenotypic changes, involves a relaxation of natural selection, as well as conscious and unconscious artificial selection (Jensen 2014). Over the course of time, the domestic chicken has become more adapted to a life very different from that in the jungle, and is *e.g.* less fearful of humans than its wild ancestor (Campler *et al.* 2009). However, the behavioural repertoire of the domestic chicken remains the same as in the red jungle fowl, although the frequency at which different behaviours are performed has changed in the former (Price 1999).

Domestic chickens in commercial production do not spend as much time foraging as jungle fowl, but spend relatively more time feeding (Schütz *et al.* 2001). However, they still allocate a substantial part of the day to scratching and pecking at the ground (Larsen *et al.* 2017), despite provision of *ad libitum* feed that meets their nutritional requirements. Roosting, especially during night-time, is also a strongly motivated behaviour, regardless of the fact that there are no predators to fear inside modern poultry houses (Olsson & Keeling 2000; Malchow *et al.* 2019). However, the threat from predators is real in production systems with outdoor access, and there the possibility to find refuge in a shrubbery or below a tree canopy is as important to the domestic chicken as in the wild (Larsen *et al.* 2017). Furthermore, chickens will dust bathe when provided with suitable substrate, perform sham dust bathing in the absence of substrate and show a rebound in dust bathing after deprivation, although the strength of their motivation to dust bathe is uncertain (Weeks & Nicol 2006; Hemsworth & Edwards 2021). Hens will work hard for access to a discrete, enclosed site for nesting and pre-laying behaviour when approaching the time for oviposition (egg laying) (Cooper & Appleby 2003; Weeks & Nicol 2006).

2.1.3 Commercial poultry production

Commercial poultry production changed considerably during the 20th Century. The aforementioned modifications made with regard to housing and production practices, and intense genetic selection for increased growth or egg laying, were conducted primarily with emphasis on enhanced production (Gunnarsson 2018). The intensification of livestock agriculture was criticised by Ruth Harrison with the publishing of her book *Animal Machines* (Harrison 1964), which promoted a public debate about farm animal welfare. It also prompted an investigation by a committee appointed by the British government, from which the Brambell Report emanated (Brambell 1965). Several initiatives to increase farm animal welfare have been adopted across Europe as a result of that report, which was also an outset for the development of animal welfare science as a new research discipline (Hemsworth *et al.* 2015). With increasing knowledge about poultry biology and behaviour, the activities of the poultry production industry (genetic selection, housing and husbandry practices) came to be influenced also by animal welfare concerns rather than solely by production goals (Appleby 2008).

A number of different poultry production systems are now in place world-wide. The central features of the main housing systems are outlined below, along with some of the dominant welfare issues in commercial broiler and egg production.

Laying hens

As a consequence of genetic selection for egg quantity and quality, the commercial laying hen produces her first egg at around 19 weeks of age, whereas in her jungle ancestor the onset of lay (in captivity) is at around the age of 25-30 weeks (Schütz *et al.* 2002). The former thereafter lays almost one egg a day, about twice the size of the red jungle fowl egg (Schütz *et al.* 2002), until the end of the production cycle at around 80-100 weeks of age (Hendrix Genetics 2022).

The majority of hens in the European Union (EU) are currently kept in enriched cages (Figure 1), which are modified versions of the preceding battery cages. Cage systems were first introduced in the early 20th Century to combat problems with intestinal parasites and issues with injurious pecking (Appleby *et al.* 2004). Cages allowed a large number of animals to be housed together, yet partitioned into small groups to avoid the spread of injurious pecking throughout the entire flock. Faecal-oral disease transmission was reduced by housing birds on wire mesh above the litter area, separating the birds from their faeces (Appleby *et al.* 2004). However, the lack of litter or any other such substrate prevented the birds from foraging or dust bathing, as did the insufficient space offered in the small battery cages, in which movement was very restricted.

Enriched cages were introduced during the 1990's to address concerns about animal welfare, by providing the hens with a perch, nest box, litter area, claw shortening device and relatively more space (Tauson 1998; Appleby *et al.* 2004). While movement is still restricted, hens in enriched cages can roost at night (although not in a very elevated position), forage in a small litter area and access a separate site for nesting. Battery cages were banned in 2012 (Council Directive 1999/74/EC), and although enriched cages are currently allowed within the EU, these will be prohibited by 2027 as a result of the European Citizens' Initiative 'End the Cage Age' (End the Cage Age 2021).

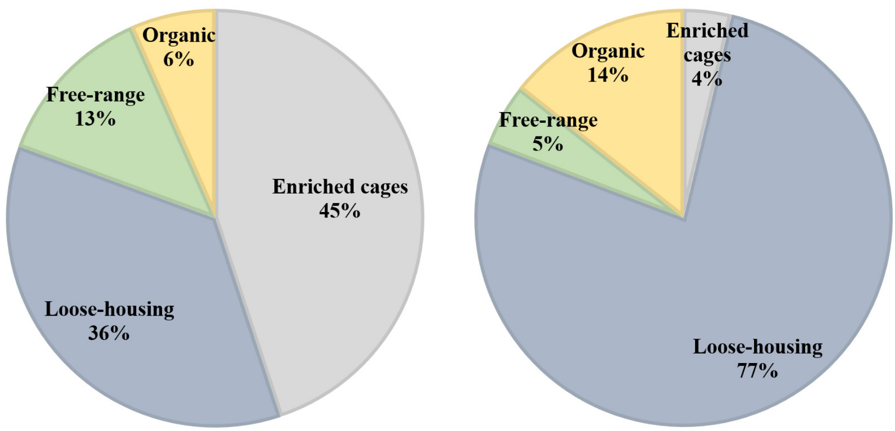


Figure 1. Proportion of laying hens kept in different housing systems in (left) the European Union and (right) Sweden in 2021 (European Commission 2021).

Alternative housing systems, *i.e.* loose-housing systems, provide the hens with litter for foraging and dust bathing, as well as space to move around and perform other *e.g.* comfort behaviours. In multi-tier systems, hens may manoeuvre between different levels and roost not only in an elevated position, but also synchronously. However, severe feather pecking, *i.e.* pecking and pulling at the feathers of a conspecific, remains one of the main welfare issues in non-cage systems (Heerkens *et al.* 2015). Severe feather pecking is a multi-factor problem and hence without a sole, straightforward solution (Jung & Knierim 2018). To mitigate the damage to the recipient bird, laying hens in many countries are beak-trimmed, *i.e.* the tip of the beak is partially removed. This procedure induces acute and chronic pain and is thus heavily debated from an animal welfare perspective (Glatz & Underwood 2021). Provision of litter, during rearing and the laying period, has been shown to prevent or reduce the development of severe feather pecking (Jung & Knierim 2018). On the other hand, a litter area in which hens scratch and peck provides favourable conditions for parasite transmission, and thus the prevalence of intestinal parasitic infections is often higher in loose-housing systems than in cage systems (Permin *et al.* 1999; Jansson *et al.* 2010). Keel bone damage, *i.e*. deviations and fractures of the sternum, is another important and more recently acknowledged welfare issue among laying hens. Although the problem extends to all housing systems (Thøfner *et al.* 2021), one of the main explanations proposed is trauma as the hens collide with the housing interior in non-cage (especially multi-tier) systems (Stratmann *et al.* 2015). High laying performance (Jung *et al.* 2019), early onset of lay and production of large eggs (Thøfner *et al.* 2021) have also been associated with keel bone fractures.

Free-range systems are similar to loose-housing systems, but include access to an outdoor area. Outdoor access provides the birds with additional space and greater opportunities for *e.g*. foraging, and may also comprise a more complex environment for them to explore (Mellor 2015c; Thuy Diep *et al.* 2018). These aspects of free-range access have been proposed as an explanation for the protective effect that free-ranging appears to have against feather pecking (Bestman & Wagenaar 2014). On the other hand, free-ranging brings the danger of both ground and aerial predators (Bestman & Bikker-Ouwejan 2020). Transmission of infectious diseases such as avian influenza, through contact with wild birds, is another major animal welfare concern in such systems. High biosecurity standards are easier to uphold in indoor housing systems, in which full control over the environment can be maintained. The outdoor area may also be a potential source of endoparasite infections (Permin *et al.* 1999), although it has been suggested that free-ranging *per se* is not necessarily a risk factor, given that hens use and disperse well throughout the range (Thapa *et al.* 2015).

Broilers

Broilers are the result of intense genetic selection for rapid growth, large muscle mass and high feed conversion efficiency (Hartcher & Lum 2020), and commercial broiler strains can now gain more than 2 kg body weight in a little more than one month (Aviagen 2022). The majority of broilers in the EU (~90%) (Augère-Granier 2019) as well as Sweden (~99%) (Swedish Board of Agriculture, 2022b) are kept in indoor loose-housing systems. Chicken meat production is one of the most intensive farming systems in the EU, and flocks often comprise several thousand birds reared in large compartments on a littered floor, with high stocking densities (Augère-Granier 2019). Biosecurity is very high, and the indoor environment, including temperature, humidity and lighting, can be controlled meticulously.

Poor leg health and lameness remains a major welfare issue in commercial broiler production, although genetic factors as well as management factors have contributed to improvements in recent years (Tahamtani *et al.* 2018). There are various infectious and non-infectious underlying causes of impaired leg health and lameness (Hartcher & Lum 2020), for which rapid growth rates and high body weight have been identified as primary risk factors (Kestin *et al.* 2001; Rauch *et al.* 2017).

As a consequence of lame broilers sitting or lying down in contact with the bedding for extended periods of time, lameness can contribute to the development of skin lesions, especially on the hocks (Kjaer *et al.* 2006). Contact dermatitis, including such hock burns as well as foot pad dermatitis, is another major welfare issue in broilers (Nicol *et al.* 2017). Macroscopic findings range from mere discoloration of the skin to deep ulcerative lesions (Michel *et al.* 2012). Poor litter quality, in particular wet or moist litter, has been identified as a main risk factor for these lesions in poultry (Jong *et al.* 2014). High stocking density can contribute to the deterioration of litter quality, with a subsequent increase in foot pad dermatitis and hock burns (Dozier *et al.* 2006). High stocking densities can also negatively affect broiler welfare due to physical restriction of movement, which may limit the behavioural repertoire and hamper access to resources (Ventura *et al.* 2012).

Broilers in commercial production are generally housed in a barren environment, without perches or any other environmental enrichment (Nicol *et al.* 2017). Although motivated to sit in an elevated position, especially at night (Malchow *et al.* 2019), they may be physically restricted from ascending and remaining on traditional perches as they become heavier (Dixon 2020). Lack of raised sitting areas has also been shown to result in disturbances amongst the birds, which has welfare implications as it disrupts rest and sleep (Ventura *et al.* 2012).

Fast-growing hybrids are by far the most commonly used within the global broiler industry (Augère-Granier 2019). However, in an attempt to mitigate the welfare issues associated with rapid growth rate, relatively more slower-growing hybrids are now also used on organic as well as non-organic farms (Nicol *et al.* 2017). These hybrids show better welfare in terms of *e.g*. lower mortality, better leg and foot health, and physical ability to perch (Sarica *et al.* 2014; Malchow *et al.* 2019; Dixon 2020). When used in organic production, the definition of 'slow-growing' is determined on national level (EU 2018/848), *e.g.* in Sweden slow-growing hybrids may have a maximum average growth rate of 45 g per day (SJVFS 2020:1).

Public concerns about broiler welfare have resulted in the emergence of various 'higher-welfare' systems, through *e.g*. private initiatives. Around 10% of the broilers in the EU are currently reared in alternatives to standard intensive production systems (Augère-Granier 2019). These include loose-housing indoor systems with *e.g*. lower stocking densities, more slower-growing hybrids and/or provision of environmental enrichment, as well as free-range systems. Organic broiler production (see below) comprises a relatively small share of the market, approximately 1%, in the EU (Augère-Granier 2019) as well as in Sweden (Swedish Board of Agriculture, 2022b).

Free-range systems may, as previously mentioned, provide the birds with a more stimulus-rich environment and greater opportunities for *e.g*. foraging, but also include exposure to predators and a higher risk of infectious disease transmission (Bonnefous *et al.* 2022). Outdoor access for broilers has been shown to be associated with better gait scores (Taylor *et al.* 2020) and a lower incidence of foot pad dermatitis (Gouveia *et al.* 2009; Dal Bosco *et al.* 2014). However, others have demonstrated a negative effect on foot pad health in free-ranging chickens (Sarica *et al.* 2014; Taylor *et al.* 2020), which is likely to be dependent on current weather and outdoor ground conditions (Sarica *et al.* 2014).

2.2 Organic agriculture

The development of organic agriculture, which first began in the 1920's and 1930's, was partly a response to the aforementioned intensification of agriculture (Baars *et al.* 2004). It involved the convergence of a number of alternative agricultural movements (including bio-dynamic, biological and ecological agriculture), some of which called for a more natural way of living and stemmed from a desire to preserve rural life and protect it from urbanisation and industrialisation. Others were motivated by a biological and more sustainable way of farming (Padel *et al.* 2004) or the holistic conviction that healthy soils give healthy food, promoting human health (Vaarst *et al.* 2004). This interest in alternative ways of food production was further roused with the growing public environmental concerns in the 1960's and 1970's (Padel *et al.* 2004). The holistic approach and the idea of an integrated agricultural system, adapted and tailored according to the local ecological context and relying on internal farm resources rather than external, is fundamental in organic farming (Box 1) (Baars *et al.* 2004; Padel *et al.* 2004).

Box 1. Definition of organic agriculture (IFOAM 2022a)

"Organic Agriculture is a production system that sustains the health of soils, ecosystems, and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic Agriculture combines tradition, innovation, and science to benefit the shared environment and promote fair relationships and good quality of life for all involved."

Initially, animals were primarily considered important as part of an integrated agricultural system, but organic farming eventually also came to include concerns for animal welfare in intensive livestock production (Padel *et al.* 2004). High animal welfare standards are now inherent to organic agriculture and, in particular, natural living and the possibility to express natural behaviours in a natural environment are regarded as critical for ensuring good animal welfare (Vaarst & Alrøe 2012).

The global organic sector has grown considerably since the late 20th Century (Reganold & Wachter 2016), as a consequence of an increasing consumer demand for organic products and also due to scientific research, political support and government initiatives (Vaarst *et al.* 2004). Whereas these alternative ways of farming began on a small scale, with individual farmers selling their products directly to the consumer, modern organic production is now subject to legal regulations and certification of products, and involves large-scale farms and international exports (Vaarst *et al.* 2004). However, this development has not been, and is still not, without an ongoing debate within the movement about how to consolidate its position in modern agriculture while continuing to grow and develop according to the values of the organic movement (Padel *et al.* 2004).

2.2.1 IFOAM – Organics International

The International Federation of Organic Agriculture Movements (IFOAM – Organics International) was founded in 1972 to promote the global organic movement. It is a global non-governmental umbrella organisation co-ordinating a world-wide network of almost 600 organic agriculture member organisations, with affiliates in nearly 130 countries (IFOAM 2022a). The IFOAM vision encompasses the world-wide adoption of organic practices in order to ensure ecologically, socially and economically sound agricultural systems in line with the four principles of organic agriculture – health, ecology, fairness and care (Box 2) (IFOAM 2022a). This vision is pursued through a wide range of activities to promote and facilitate global uptake of organic agriculture.

Box 2. The four principles of organic farming (IFOAM 2022a)

Principle of Health. Organic agriculture should sustain and enhance the health of soil, plant, animal, human and planet as one and indivisible. It is not simply the absence of illness, but the maintenance of physical, mental, social and ecological well-being.

Principle of Ecology. Organic agriculture should be based on living ecological systems and cycles, work with them, emulate them and help sustain them. Production should be based on ecological processes, and adapted to local conditions. Inputs should be reduced by reuse and recycling.

Principle of Fairness. Organic agriculture should build on relationships that ensure fairness, characterized by equity, respect, justice and stewardship of the shared world, both among people and in their relations to other living beings and the common environment. Organic agriculture should provide everyone involved with a good quality of life.

Principle of Care. Organic agriculture should be managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment. Appropriate technologies should be adopted, and unpredictable technologies rejected, based on science as well as practical experience, accumulated wisdom and indigenous knowledge.

With the purpose of harmonising the organic concept and what it encompasses, the organisation has developed internationally applicable organic standards. The 'IFOAM Basic Standards' were first published in 1980. In 2012, they were replaced by the 'IFOAM Standard for Organic Production and Processing', with the addition of the 'Common Objectives and Requirements of Organic Standards (COROS) – IFOAM Standards Requirements'. The IFOAM Standards serve as a reference against which private and governmental organic standards implemented on national and regional level may be assessed, in order to evaluate how well a particular standard addresses the common objective outlined in the former. The ultimate aim is to allow the fundamental values of the movement and the four principles of organic agriculture to be fulfilled at farm level. However, the IFOAM Standards represent a compromise between different values, as well as between these and what is in fact feasible considering contemporary farming methods and the present market situation (Vaarst *et al.* 2004). The standards provide guidance to producers on how to implement the organic principles throughout the production chain and, through a certification process for organic products, provide assurance of product quality at the consumer level (Padel *et al.* 2004).

Although not always explicitly stated, high animal welfare standards can be found embedded in each of the four principles of organic agriculture (Box 3) (Vaarst & Alrøe 2012). Through private and governmental organic standards, which allow the underlying values of organic agriculture to be embodied in practical farming methods, the organic principles can be recognised in current production practices and on the individual farm (Vaarst *et al.* 2004).

The IFOAM Standards entail, in brief, the following requirements and recommendations concerning animal husbandry:

- Organic management practices should promote and maintain the health and well-being of animals through balanced organic nutrition, stress-free living conditions and breed selection for resistance to diseases, parasites and infections
- Breeds must be adapted to local conditions
- Mutilations are prohibited
- Animals must not be kept in closed cages
- All animals must have unrestricted and daily outdoor access, whenever the physiological condition of the animal, the weather and the state of the ground permit
- Animals must be protected from predation by wild and feral animals
- The environment, stocking density and flock size must allow opportunities to express normal patterns of behaviour
- To satisfy the needs of the animals, sufficient fresh air, water, feed, thermal comfort, natural daylight and suitable materials and areas for exploratory and foraging behaviours must be provided
- When welfare and health problems occur, appropriate management adjustments must be implemented (*e.g.* reduced stocking density)
- If an animal becomes sick or injured despite preventative measures, that animal must be treated promptly and adequately
- Prophylactic use of any synthetic allopathic veterinary drug is prohibited (vaccinations are allowed when legally required or necessary to control endemic disease).

Box 3. The four principles of organic farming and animal welfare. Based on Vaarst & Alrøe (2012).

Principle of Health. This principle relates to the health of the individual animal and the herd. Health is more than merely the absence of disease and high performance – a healthy animal is one in homeostasis, whose immune system and disease resistance are strengthened. Health promotion is thus different from disease prevention.

Principle of Ecology. This principle links closely to naturalness and allowing the animal to feed, live, and behave to fulfil its natural needs regarding physiology, psychology and anatomy. Appropriate breeds for the context must be chosen to achieve this.

Principle of Fairness. Fairness towards individual animals implies fair treatment in all situations throughout life. Animals should be provided with the conditions and opportunities of life that accord with their physiology, natural behaviour and well-being. It also involves the concept of animal integrity. This includes that their surroundings should be designed to fit the animals, rather than mutilating animals.

Principle of Care. This principle reflects human interaction with animals, and involves the human responsibility to protect, intervene and interact wisely and with humaneness.

2.2.2 EU regulations on organic farming

Organic production and marketing have been regulated in the EU since 1991, at first including only crop production, with EU regulations on organic animal husbandry introduced in 1999. Until recently, the EU requirements for organic animal production were set by regulation (EC) No. 834/2007 and the implementing regulation (EC) No. 889/2008, which was replaced by the organic regulation (EU) 2018/848 as from January 1st, 2022.

Governmental and private organic standards on regional or national level that successfully pass an assessment against the IFOAM Standards are included in the 'IFOAM Family of Standards'. The EU organic regulations were included in 2013 (IFOAM 2022b). A general objective of the current EU organic regulations is to contribute to high animal welfare standards and, in particular, to meeting the species-specific behavioural needs of animals. Husbandry practices, including stocking densities, housing conditions and choice of breeds, must ensure that the developmental, physiological and ethological needs of the animals are met (EU 2018/848).

While not intended as a comparison between organic and non-organic poultry production systems, but rather to highlight some of the specific features of organic poultry production, the minimum requirements as laid down by the respective EU regulations are presented in Tables 1 and 2.

2.2.3 KRAV

KRAV® is a Swedish private organic incorporated association founded in 1985, and the main national organisation for organic agriculture (KRAV 2022a). The requirements for production of KRAV-labelled products are stipulated in the 'KRAV Standards', which cover the entire production chain from primary production to sales and marketing, and encompass a variety of enterprises, *e.g*. crop production, animal husbandry, apiculture, aquaculture, food processing and slaughter (KRAV 2022b). Independent certification bodies perform audits and KRAV certification. The standards are developed together with producers, consumers and environmental organisations, researchers and the business sector, and established based on what is considered feasible in the present context. They are reviewed on a continual basis and an updated book of standards is published at least every other year.

KRAV is a member of IFOAM – Organics International, and the KRAV standards are included in the IFOAM Family of Standards (KRAV 2022a). The KRAV standards comply with, but go further than, the EU regulations by requiring *e.g*. provision of specific sand baths indoors or on the veranda; a maximum stocking density of 10 birds/m^2 or 20 kg/m^2 (broilers); at most six birds per single nest (laying hens); and lifting broilers by holding the body around the wings and carrying them upright (KRAV 2022b).

Table 1. Minimum standards for the housing and management of laying hens in non-organic (Council Directive 1999/74/EC), with reference to alternative housing systems, and organic (EU 2018/848; EU 2020/464) egg production in the European Union

	Non-organic	**Organic**
Nest space	7 birds per single nest or 1 m^2 for a maximum of 120 hens in group nests	7 birds per single nest or 120 cm^2 per bird in group nests
Perches (cm per hen)	15	18
Litter area	250 cm^2 per hen and 1/3 of floor area	1/3 of floor area
Outdoor access	Not required	1/3 of life and 4 m^2 per hen[1]
Stocking density (hens per m^2 usable area)	9	6
Cages	Enriched cages permitted[2]	Not permitted
Lighting	Light levels sufficient to see one another, investigate the surroundings and display normal activity levels	Natural light
Nocturnal rest (hours per day with no artificial light)	About 1/3 of the day	8 hrs continuous
Mutilation (beak trimming)	Permitted in order to prevent feather pecking and cannibalism (<10 days old)	Only permitted in exceptional cases (≤3 days old)
Flock size	No upper limit	3000 birds per section
Roughage	No requirement	Permanent access to sufficient quantities when kept indoors
Dietary synthetic amino acids	Permitted	Not permitted
Prophylactic antibiotics	Antibiotics, other than coccidiostats or histomonostats, are not permitted as feed additives[3]	Substances to promote growth or production (including antibiotics, coccidiostats and other artificial aids for growth promotion) shall not be used for preventive treatment

[1]Whenever weather and seasonal conditions allow, and except when temporary restrictions have been imposed.
[2]Currently allowed, but will be prohibited by 2027 (End the Cage Age 2021).
[3]Stipulated in regulation (EC) No.1831/2003.

Table 2. Minimum standards for the housing and management of broilers in non-organic (Council Directive 2007/43/EC) and organic (EU 2018/848; EU 2020/464) meat chicken production in the European Union

	Non-organic	Organic
Stocking density (kg/m^2)	33[1]	21
Litter area	Permanent access to litter	1/3 of floor area
Lighting	20 lux max. illuminating at least 80% of the area[2]	Natural light
Nocturnal rest (hours per day with no artificial light)	6, of which 4 continuous	8 continuous
Mutilation (beak trimming)	Permitted in order to prevent feather pecking and cannibalism (<10 days old)	Only permitted in exceptional cases (≤3 days old)
Outdoor access	Not required	1/3 of life and 4 m^2 per chicken[3]
Raised sitting areas	Not required	5 cm perch per bird and/or 25 cm^2 raised sitting level per bird
Growth rate	Fast-growing breeds permitted	Slow-growing breeds, or reared to a minimum age of 81 days[4]
Flock size	No maximum limit	4800 per section
Roughage	No requirement	Permanent access to sufficient quantities when kept indoors
Dietary synthetic amino acids	Permitted	Not permitted
Prophylactic antibiotics	Antibiotics, other than coccidiostats or histomonostats, are not permitted as feed additives[5]	Substances to promote growth or production (including antibiotics, coccidiostats and other artificial aids for growth promotion) shall not be used for preventive treatment

[1]Up to 42 kg/m^2 are allowed provided that certain requirements are complied with.
[2]Temporary reduction may be applied when necessary.
[3]Whenever weather and seasonal conditions allow, and except when temporary restrictions have been imposed.
[4]Slow-growing defined by national competent authority.
[5]Stipulated in Regulation (EC) No.1831/2003.

2.3 Animal welfare

Simply put, 'animal welfare' is concerned with what is good and bad for an animal, from the animal's perspective (McCulloch 2012). Various definitions of animal welfare have been proposed and discussed over recent decades (Appleby 2008; Mellor 2016a). At present, animal welfare is commonly regarded as a multifaceted concept involving three main aspects: (i) health and normal bodily functioning, (ii) natural living and the ability to express natural behaviour, and (iii) subjective feelings (affective states) (Fraser *et al.* 1997). Initially, animal welfare was often defined in terms of only one of these three perspectives, which were in general considered separately and independently of each other, but they are now widely accepted as interrelated and to some extent overlapping (Fraser *et al.* 1997; Mellor 2016a).

Animal welfare has been defined as "[an animal's] state as regards its attempts to cope with its environment" (Broom 1996). Initially, this referred predominantly to the extent of biological costs (*e.g.* health, growth or reproductive impairments) resulting from an animal's attempts to manage more or less severe challenges in life. The health status of an animal would thus reflect whether it is coping well, with some or with considerable difficulty, or not at all (Hemsworth *et al.* 2015). This definition later came to encompass also the feelings associated with more or less successful coping attempts (Broom 1996).

Natural living as important for animal welfare involves the ability of animals to live according to their 'nature' (Rollin 1993), *i.e.* in an environment including natural elements, and which allows for the performance of natural species-specific behaviours (Vaarst & Alrøe 2012). This notion has been criticised due to the difficulties in determining what is in fact natural for a domestic animal, which may be and live very differently from its wild ancestor (Hemsworth *et al.* 2015). Another interpretation put forward is that life in accordance with an animal's nature is one that corresponds to the animal's set of adaptations, and that promotes normal (for the species) ontogenic development (Fraser *et al.* 1997).

Other perspectives on animal welfare are concerned foremost with the subjective feelings of animals, and advocates of this approach have argued that for something to influence the welfare of an animal, it must influence its affective state (Duncan 1996). In other words, the welfare of a sick animal would be impaired only if that sickness negatively affects how the animal feels (Hemsworth *et al.* 2015). Human concern for animal welfare is thus based on an acknowledgement of animal sentience, *i.e.* the ability of an animal to feel and experience negative as well as positive emotions that matter to the individual (Duncan 2006). Animal welfare in terms of subjective feelings is often considered as the balance between positive and negative affect (Yeates & Main 2008; Webb *et al.* 2019). More recently, it has been conceptualised as 'animal happiness', *i.e.* how an animal feels most of the time (Webb *et al.* 2019).

These three perspectives can be found embedded in other treatments of animal welfare, although not always explicitly phrased in terms of this multidimensional concept encompassing the animal's body, nature and mind.

'The Five Freedoms' is a well-renowned framework for the evaluation of animal welfare, which was developed by the Farm Animal Welfare Council (FAWC) in 1979 (FAWC 2009) based on the Brambell Report (Brambell 1965). The Five Freedoms were later complemented by 'The Five Provisions', which present practical advice on how to achieve the freedoms (Box 4) (McCulloch 2012).

Box 4. The Five Freedoms (and their aligned Five Provisions)

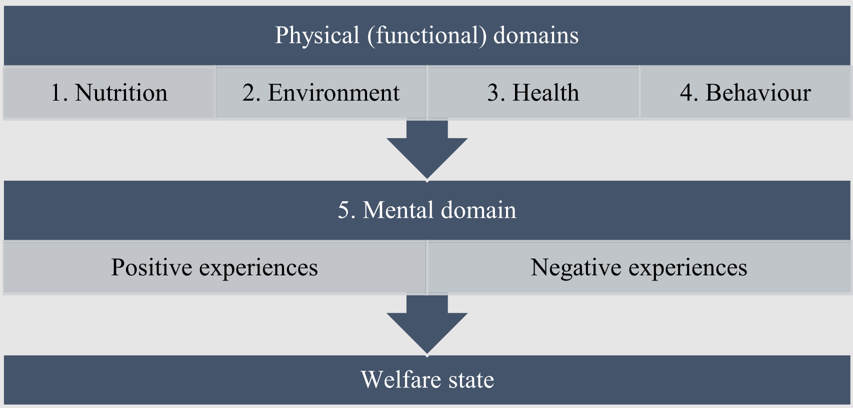
1. *Freedom from thirst, hunger and malnutrition* by ready access to fresh water and a diet to maintain full health and vigour.
2. *Freedom from discomfort* by providing a suitable environment including shelter and a comfortable resting area.
3. *Freedom from pain, injury or disease* by prevention or rapid diagnosis and treatment.
4. *Freedom to express normal behaviour* by providing sufficient space, proper facilities and company of the animal's own kind.
5. *Freedom from fear and distress* by ensuring conditions which avoid mental suffering.

For many years the Five Freedoms were prominent in animal welfare discussions in Europe (McCulloch 2012). However, this framework has received criticism for the phrasing of the Five Freedoms as ideal animal welfare states (although "freedom from" was meant to be interpreted as "as free as possible from"), as it does not provide any indication of what is an acceptable level of animal welfare (McCulloch 2012; Mellor 2016b). Criticism has also been directed at the framework for its emphasis on prevention of poor welfare, rather than promotion of good welfare (McCulloch 2012; Mellor 2016b).

To begin with, the primary aim of animal welfare management was indeed to minimise unpleasant experiences and negative affective states, and animal welfare concerns were mainly focused on meeting the animals' basic needs for *e.g.* food, water, enough space and the avoidance of injury or disease (Yeates & Main 2008). However, animal welfare discussions and research have gradually developed to include the concept of 'positive welfare', *i.e.* promotion of pleasant affective states and rewarding experiences (Yeates & Main 2008; Mellor 2016b). It is now widely accepted that merely minimising unpleasant experiences and negative affective states in animals does not *per se* secure *good* animal welfare. Hence, animal welfare frameworks succeeding the Five Freedoms now also explicitly include promotion of positive welfare (Mellor 2016b; Webb *et al.* 2019)

'The Five Domains Model' (Box 5) for animal welfare assessment was developed in 1994 (Mellor & Reid 1994). Unlike the Five Freedoms, the Five Domains Model (i) provides a framework to grade the severity of welfare compromise, and (ii) differentiates between physical or functional (*e.g.* malnutrition or injury) and affective (*e.g.* hunger or pain) elements of animal welfare (Mellor 2016a).

Box 5. The Five Domains Model



Within this framework, a distinction is also made between negative affects that are crucial for the survival of the animal (*e.g*. thirst to provoke finding water), which are at best neutralised, and negative affects that reflect the animal's perception of its external circumstances (*e.g*. fear or boredom), which can often be replaced by positive affects under different conditions (Mellor 2016a). The first four domains are physical or functional, while the fifth is to be understood as the overall subjective (or affective) outcome of both negative and positive affects stemming from the other four domains, representing the animal's overall welfare state (Mellor 2016b).

Overall welfare, not only at a particular point in time but over an extended period, has been conceptualised as the 'Quality of Life' of animals (McMillan 2000; Yeates 2011). It relates to the balance between positive and negative experiences (or pleasant and unpleasant feelings), *i.e*. the composite measure of the overall affective status of an individual animal (McMillan 2000). The weighing of positive and negative must take into account the valence and duration of all relevant experiences (Yeates 2011), as well as the individual animal's personality and preferences (McMillan 2000). Affective states are central to the concept and for something to influence the animal's quality of life, it must influence how the animal feels (McMillan 2000).

When taking into account every experience throughout the entire life of an animal, from birth to death, the overall value of the animal's life may be considered along a continuum (Yeates 2011). Overall welfare can be considered to have an overall positive or negative value, and the life of an animal may be considered good, worth living, worth avoiding, or not worth living, depending on the composite value of all the experiences involved (Yeates 2011). The overall balance will be negative if the unpleasant experiences of an animal outweigh the pleasant, and hence its life will not be worth living. For a life to be a life worth living, the overall balance of pleasant experiences must outweigh the unpleasant experiences across the animal's lifetime (Yeates 2011).

2.3.1 Assessment of animal welfare

What is considered to improve or impair animal welfare, from a human perspective, depends on underlying individual presumptions about what is better or worse for an animal (Fraser *et al.* 1997). People will have different views on what is, or is not, important for animal welfare, and thus value notions and normative elements are inherent to the concept (Fraser 1995;

McCulloch 2012). The relative importance ascribed to the different aspects involved in the assessment of animal welfare, and the weighting of these for an overall welfare outcome, must thus result from a subjective process. However, scientific research may generate germane information that contributes to a better understanding of animal welfare (Fraser 1995; Fraser *et al.* 1997; Appleby 2008). Animal welfare science can provide a common foundation of relevant knowledge, regarding *e.g.* the evolution of a species, animal cognition, emotions, preferences and motivation to perform different behaviours, as well as nutritional requirements, physiology, and health.

Research on animal welfare is also concerned with developing methods for the assessment of animal welfare (Hemsworth *et al.* 2015). While the overall welfare of an animal cannot be measured by one single indicator, there are scientifically validated methods for measuring a number of factors considered to influence welfare (Fraser 1995). In brief, such 'animal welfare indicators' include *e.g.* measures of body condition, health and disease, production, physiology, behaviour, environmental aspects and provision of resources (Welfare Quality 2009). The feelings of an individual animal can never be known and there is no way to measure or quantify mental experiences directly (Yeates 2011). However, various observable external indicators of an animal's internal mental experiences have been identified, including *e.g.* facial expressions, postures, vocalisations, response to novelty, cognitive bias and a number of other behavioural and physiological indicators (Mellor 2015a; Webb *et al.* 2019).

Welfare indicators are in general categorised as: (i) 'resource-based measures', which involve the animal's environment, *i.e.* stocking density, outdoor access and other resources such as *e.g.* food, water and environmental enrichment; (ii) 'management-based measures', which relate to procedures such as beak trimming, daily inspections of animals and treatment of diseased individuals; and (iii) 'animal-based measures', which are those that focus on the state of the animal and thus comprise health status, physiological measures of *e.g.* stress and behaviour (EFSA 2012). There has been a transition from concentrating on the first two of these to looking also at the animals, rather than at their environment only, and a combination is now considered imperative for the best possible welfare assessment (EFSA 2012).

While people may disagree on the specific indicators that are more important, it is widely recognised that a comprehensive evaluation of overall welfare requires the assessment of a variety of measures (Fraser 1995). Science cannot provide an objective method of merging or adding up these different indicators to a composite score that represents the overall net welfare of an animal (Fraser 1995). However, there is now the Welfare Quality® assessment protocol (a science-based assessment tool combining resource- and management-based measures with animal-based measures), which attempts to do this by aggregating separate indicators (Welfare Quality 2009).

When a welfare assessment involves multiple animals, such as the large groups or herds in modern animal farming systems, it becomes challenging to look at animal-based measures for each and every individual. Thus, assessment of farm animal welfare is generally performed at group level and may involve a sample of animals or the flock prevalence of disease (Lundmark Hedman *et al.* 2015), as well as information accessed post-slaughter (Welfare Quality 2009).

2.3.2 Ethics of animal farming

Ethics is the philosophical study of what is right and wrong, *i.e.* the critical reflection upon how and why humans ought to act in certain ways. Animal ethics is concerned with how humans ought to act towards animals, and the moral justifications for treating animals in a certain way in a given situation.

The moral obligations of humans towards animals depend on whether, and the degree to which we believe that animals must be given moral consideration. The most common view, and the basis for societal animal welfare concerns, is that any sentient being deserves moral consideration (Sandøe & Christiansen 2008), as reflected in the Treaty of the Functioning of the European Union (OJ C 326, 26.10.2012). However, different moral principles and values underlie individual attitudes to the use of animals for human purposes, and thus there are different views within society regarding what humans are entitled to do to animals (Sandøe & Christiansen 2008).

As mentioned, scientific research can provide empirical data for the assessment of animal welfare, but any assessment is ultimately aligned by an ethical reflection upon what factors are most important for, and what constitutes morally acceptable, animal welfare (Sandøe *et al.* 2003).

What humans may or may not do to *e.g.* farm animals is regulated in animal welfare legislation and standards. These regulations comprise an ethical component, as they provide a baseline reflecting what is generally considered morally acceptable on societal level (Sandøe *et al.* 2003). Thus, based on scientific research as well as ethical considerations while also taking into account the interests of various stakeholders, animal welfare legislation serves the purpose of protecting animals from unnecessary suffering and minimising harm, while allowing the use of them to continue (Sandøe & Christiansen 2008; Aaltola & Wahlberg 2015).

3. Aims of the thesis

The overall aim of this thesis was to provide a more comprehensive view of the welfare situation on organic poultry farms by:

- Investigating the animal welfare status on organic broiler farms and laying hen farms in Sweden
- Assessing the findings in terms of different animal welfare definitions and frameworks
- Evaluating how the observations on broiler and laying hen farms aligned with relevant organic standards.

Specific objectives of the broiler and laying hen study, respectively, were to:

- Gather information and extend the limited knowledge of bird health, behaviour, outdoor access and free-ranging, and production practices, in order to describe the present welfare situation and practical solutions applied on organic broiler farms in Sweden (Papers I & II)
- Describe the present welfare situation on organic laying hen farms in Sweden, in terms of bird health and behaviour, and evaluate the results against findings in previous relevant research (Paper III)
- Describe the present situation on commercial organic laying hen farms in Sweden in terms of outdoor access and bird ranging behaviour, and explore practicable methods to improve bird ranging, along with farmers' experiences and perspectives of free-ranging (Paper IV)
- Identify areas of relevance for future research (Papers I-IV).

4. Materials and Methods

Data collection was performed on commercial organic broiler farms (Papers I & II) and organic laying hen farms (Papers III & IV) in Sweden. All participating farms were certified according to KRAV standards. A detailed description of the materials and methods employed can be found in the respective papers.

4.1 Ethical statement

The work comprised behavioural observations and clinical scoring of broilers and laying hens on commercial farms, but no invasive treatment. Thus, approval by an ethics committee for animal experiments was not required according to Swedish legislation (SJVFS 2019:9). The studies did not include the collection of any sensitive personal data, and hence no ethical review for research involving humans was required under Swedish law (SFS 2003:460).

4.2 Farms and flocks

The broiler study (Papers I & II) included eight organic broiler farms, visited during one day each. Farm visits were performed as late in the production cycle and as close to slaughter as possible, yet while the chickens still had outdoor access (*i.e.* before pop-holes were closed for the winter). The median (min-max) flock age at the time of visit was 56 (44-62) days. Rowan Ranger and Hubbard JA57/Hubbard JA87, both slower-growing hybrids, were reared in mixed-sex flocks on five and three farms, respectively. The average flock size (mean ± SD) was 4217 ± 1290 and the average farm size (total number of birds) was 8975 ± 1688.

The laying hen study (Papers III & IV) included 11 organic laying hen farms, visited during one day each. The median (min-max) flock age at the time of visit was 74 (73-78) weeks. Hybrids included Bovans White (n=9), Bovans Brown (n=1) and Lohmann Selected Leghorn (LSL) (n=1). The median (min-max) flock size at the time of visit was 5750 (1118-17 373) and farm size was 18 000 (3000-120 000).

4.3 Data collection

The farmers and/or bird caretakers on the participating farms were interviewed according to a structured protocol that included questions on general farm structure, management and husbandry routines, housing, bird health and behaviour, production, outdoor access and free-ranging behaviour. Indoor observations comprised an assessment of dust levels and litter quality, and recording of house and veranda dimensions, number and/or dimensions of (as applicable) windows, pop-holes, drinkers and feeders, environmental enrichment items, nests, tiers and perches.

One flock per farm was selected for observation. Behavioural observations on each flock comprised an avoidance distance test, a stationary person test, a novel object test (for laying hens only) and recording the number of broilers using the different environmental enrichment items (*i.e.* positioned on top of, adjacent to or pecking at an object, as applicable). The behaviour of a group of birds in the rearing compartment (birds within an imaginary semi-circle with radius 5 m in front of the observer) was continuously observed during five consecutive minutes (see Papers II & III for ethograms). Scan-sampling behavioural observation of birds in and adjacent to (in direct contact with) the pop-holes was performed during five consecutive minutes.

In each flock, 50 birds were clinically examined (see Papers I & III for scoring protocols), and gait scoring was performed on an additional 50 broilers (Paper I).

During outdoor observations, the total number of birds and their distribution in the range were estimated. The free-range area was assessed in terms of proportion covered by vegetation cover (*i.e.* trees, bushes and tall grass) and by pasture (soil or low grass), as well as type and number of any artificial shelters (see Papers II & IV for assessment protocols).

4.4 Statistical analysis

Data collection involved a selection of measures from the Welfare Quality® assessment protocol for poultry, but with no aggregation of scores or classification of farms according to the protocol (Welfare Quality 2009). Microsoft Excel (2016) was used for data compilation and diagram creation. First, data were thoroughly explored visually to look for any patterns and possible correlations. Patterns and correlations detected were further investigated through statistical analyses performed in R (R, 2020). Pearson's Chi-squared tests and Fisher's exact tests were used to analyse any associations between different health parameters (Papers I & III). The effect of certain environmental factors on a number of health parameters was analysed through logistic regression models (Paper I) and generalised linear mixed-effects models (Paper III). Results are presented as mean ± standard deviation for normally distributed variables and as median (min-max) for non-normally distributed count variables. Results were considered statistically significant at $p<0.05$.

5. Summary of results

Below is a summary of the results from the broiler and laying hen studies. For a comprehensive presentation of the results, see Papers I-IV.

5.1 Broiler study (Papers I and II)

Three of the broiler farms studied farms received day-old Hubbard chicks whereas five farms received Rowan Ranger eggs for on-farm hatching. All farms had specific arrival rooms in which chicks were kept until around three weeks of age, when they were moved to the rearing compartment. All flocks were slaughtered at the same KRAV-certified abattoir, between 53 and 69 days of age. Thinning was performed on three of the farms.

5.1.1 Indoor environment

The dust sheet test results showed no or minimal evidence of dust on all farms. No birds were observed panting or huddling during any of the farm visits. Wood shavings only, or in combination with peat or straw, were used as litter material on all farms except one, on which straw only was used. Apart from two farms on which moderate litter deterioration was observed, litter quality across farms was good (completely dry and flaky) or slightly deteriorated (dry but not easy to move with the foot) (Figure 2).

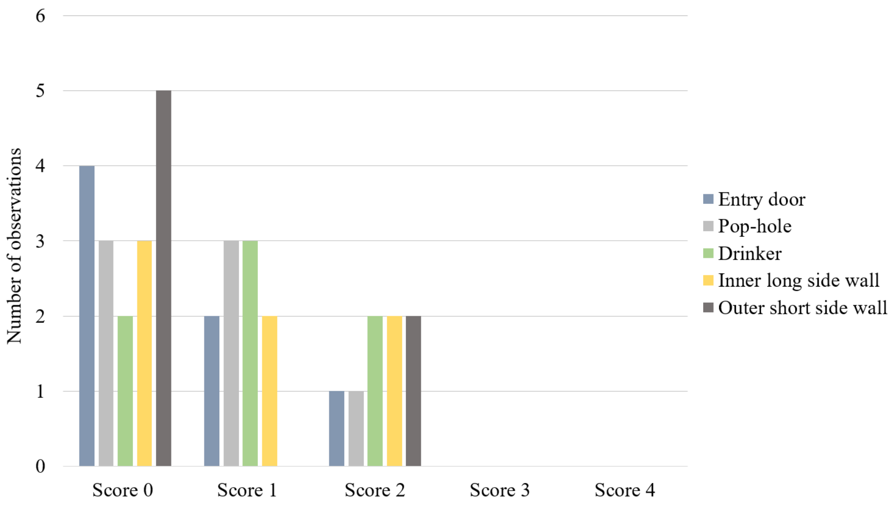


Figure 2. Litter quality assessment scores on organic broiler farms (n=7). Number of observations with score 0 (litter completely dry and flaky) to 4 (litter sticks to boots once compacted crust is broken) at five standardised locations in-house.

Environmental enrichment (raised sitting areas) was provided on all farms, as reported by the farmers. On all farms except one, an assortment of different items was observed in the rearing compartments during farm visits (Figure 3). Five of the farmers provided roughage (silage, hay, lucerne hay and/or straw) year-round, whereas three did so only when the birds had no outdoor access.

5.1.2 Health

The median prevalence of dirty plumage per flock was 42% (14-96). The majority (88%) of all chickens observed with dirty plumage had slightly dirty plumage. There was a significant correlation between plumage cleanliness and body weight (p<0.001) and age (p<0.05), *i.e.* the occurrence of dirty plumage increased as body weight and age increased.

The median prevalence of foot pad dermatitis per flock was 15 (0-58) %. The majority (92%) of the affected chickens had minor lesions and none was observed to have severe foot pad dermatitis. The median prevalence of hock burns per flock was 13 (0-26) %. Minor lesions only were observed, and no moderate or severe lesions. The occurrence of hock burns increased significantly with increasing body weight (p<0.001), whereas the occurrence of foot pad dermatitis did not (p=0.64). There was a significant correlation

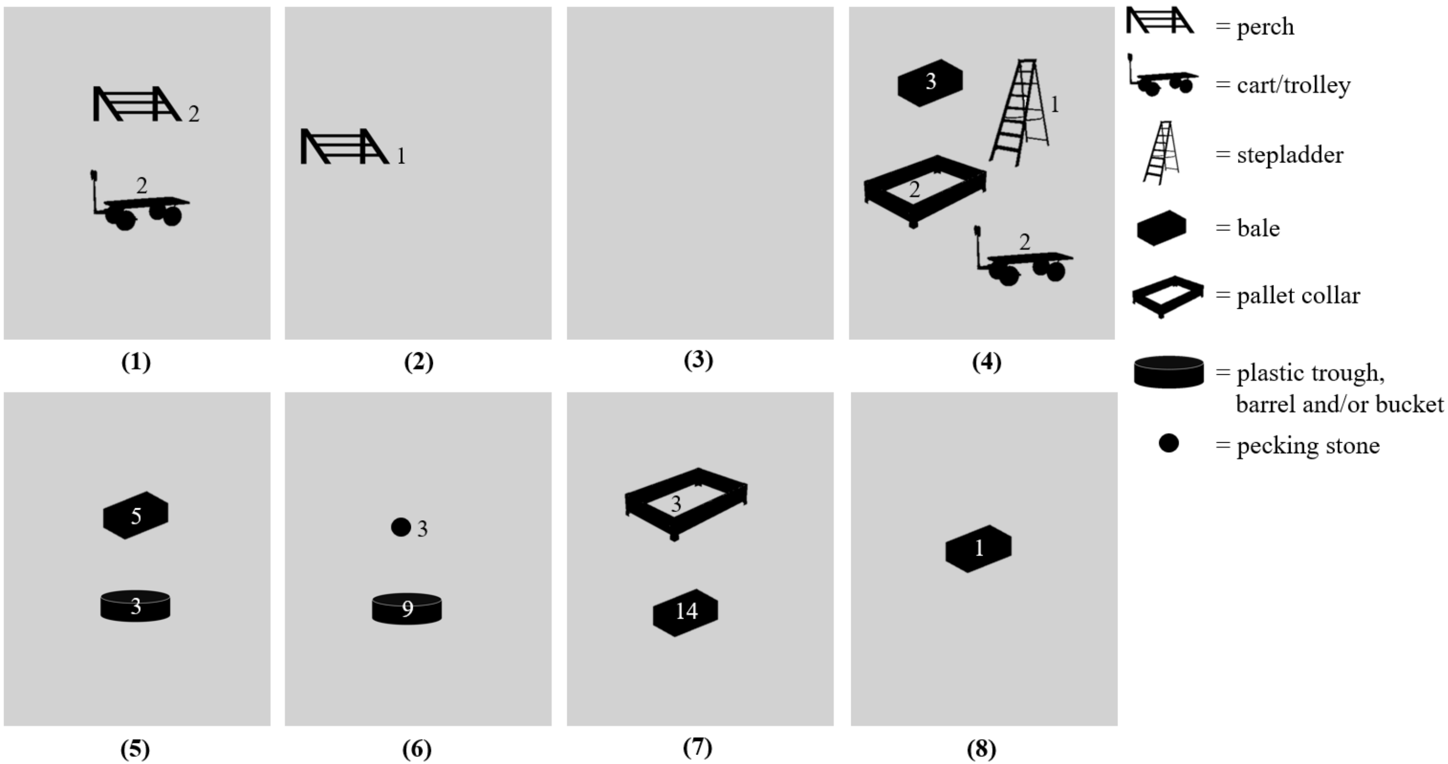


Figure 3. Schematic illustration of environmental enrichment items observed on organic broiler farms (n=8).

between higher (worse) litter scores and the occurrence of foot pad dermatitis ($p<0.001$) and hock burns ($p<0.01$). There was a significant positive association between foot pad dermatitis and dirty plumage ($p<0.01$), and between hock burns and dirty plumage ($p<0.001$).

Gait scores were significantly lower (better) in birds gait-scored outdoors than in birds assessed indoors ($p<0.001$). The proportion of birds observed without gait anomalies was more than twice as large among birds outdoors than indoors (Figure 4). No birds were observed with severe walking impairments. Gait scores were significantly higher ($p<0.05$) in flocks with higher average flock body weight (≥2594 g) than in flocks with lower average flock body weight (<2150 g). No correlation between age and gait scores was found ($p=0.11$).

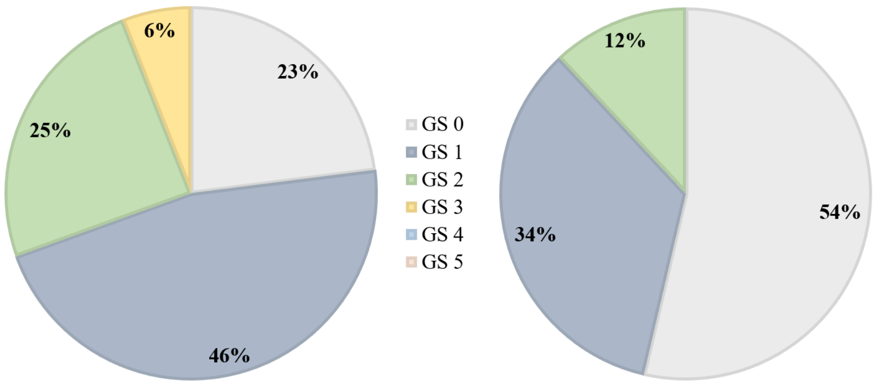


Figure 4. Proportion of chickens (n=300) with gait score (GS) 0 (normal, dextrous and agile) to 5 (incapable of walking) observed indoors (n=149) (left) and outdoors (n=151) (right) on organic broiler farms (n=6).

Average flock body weight ranged between 1947 and 2800 g. Average daily weight gain was 45-50 g (though sometimes up to 52 g), as reported by the farmers. Flock body weight uniformity, expressed as coefficient of variation, was 15.0±2.8. The coefficient of variation was significantly ($p<0.05$) higher (*i.e.* flock body weight uniformity lower) in Rowan Ranger flocks (M=16.5, SD=2.4) than in Hubbard flocks (M=12.5, SD=0.7).

The median prevalence of chickens with diarrhoea per flock was 10 (0-44) %.

5.1.3 Behaviour

During the continuous group behavioural observations, the most common behaviour observed (estimated percentage of the majority behaviour for each bird during five minutes) was sitting (on average 48% of the chickens), followed by standing (13%), walking (12%), preening (9%) and foraging (7%). The most common behaviours observed during pop-hole behavioural observations were standing, sitting and foraging, for which the median number of observations per pop-hole was 10 (0-23), 3 (0-16) and 2 (0-14), respectively (see Paper II for details).

On the first seven farms visited, no chickens were touched or counted at arm's length in five avoidance distance test trials. On the eighth farm visited, two birds were touched and one bird was counted at arm's length.

Wooden perches, a cart and the rim of pallet collars were used by a large number of broilers for sitting on, while only a few birds were observed sitting on a stepladder, upside-down plastic barrels or buckets. The broilers were also commonly observed sitting tightly clustered around especially a cart, pallet collars, straw bales and upside-down plastic barrels.

5.1.4 Free-range(ing)

Outdoor access was first provided between 23 and 30 days of age. On all broiler farms, free-range access throughout the year was largely weather-dependent and normally provided from spring (March-May) until autumn (September-November). During this period, the chickens in general had access to the free-range area from 07.30-08.30 h until dark. Continuous access (*i.e.* also during the night) to the free-range or veranda was provided in summertime on one and three of the farms, respectively.

The free-range areas on most farms consisted mainly of pasture, with little or no protective (high) vegetation cover. The latter was typically restricted to a particular area of the range (Figure 5). Artificial shelters were provided on five of the farms, generally within 25 m from the veranda.

The estimated proportion of broiler chickens ranging at the time of visit was 0-6% on seven of the farms and 21.5% on the eighth farm. The majority of chickens in most flocks were observed ranging within 25 m, and at most 55 m, from the veranda. On all farms except one, the maximum distance from the winter garden to where a bird was observed corresponded to the point at which there were no more artificial shelters or protective vegetation cover.

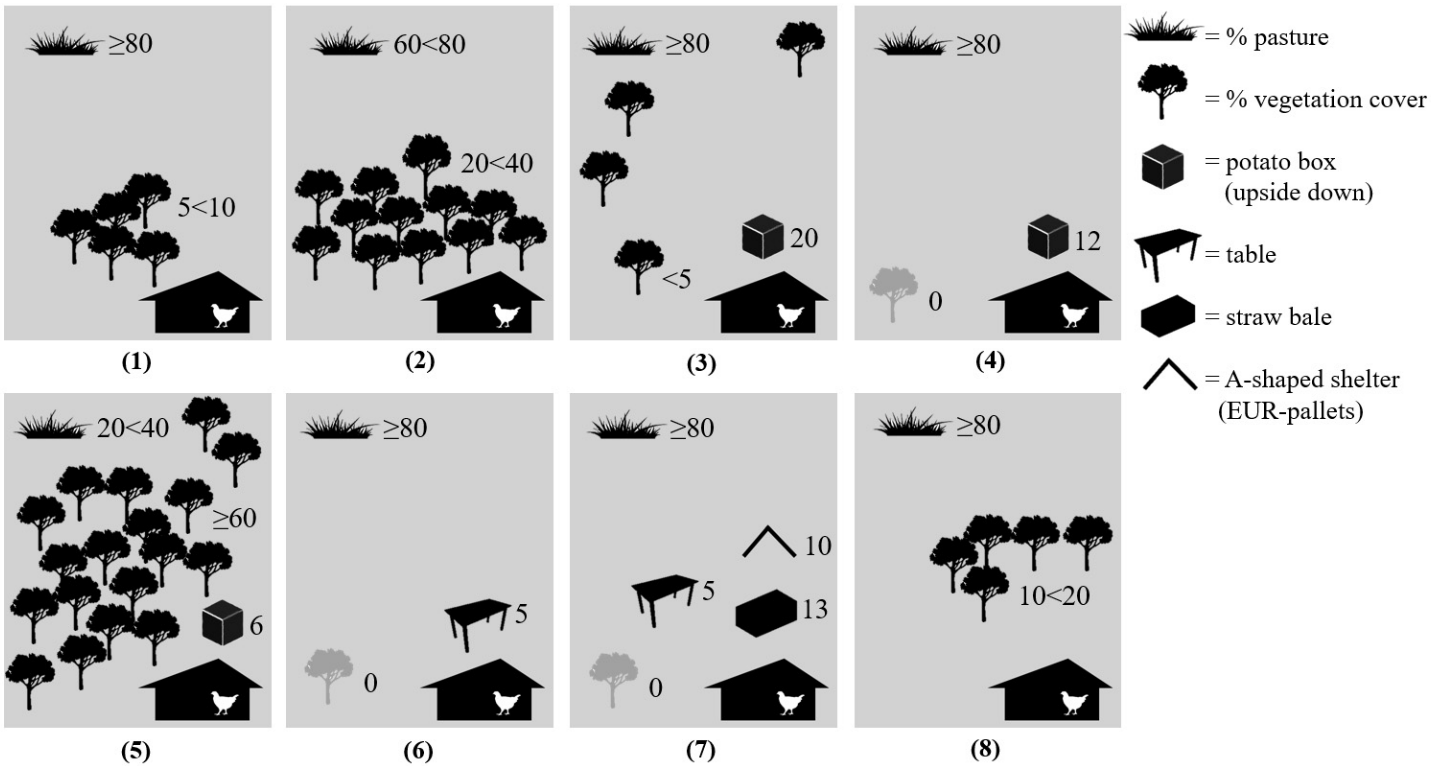


Figure 5. Schematic illustration (note: not to scale) of vegetation dispersion and artificial shelters in free-range areas on organic broiler farms (n=8).

Three farmers considered ground and/or aerial predators to be a significant problem. Foxes (*Vulpes vulpes*), badgers (*Meles meles*) and birds of prey were mentioned specifically. The remaining farmers reported no, minor or occasional problems with ground and/or aerial predators. On five farms the free-range area was surrounded by a robust wildlife fence, whereas three were not completely enclosed and/or the fence was slacking considerably in places.

5.2 Laying hen study (Papers III and IV)

Pullets were placed on the laying farms at 15 or 16 weeks of age and had in general been reared without outdoor access. All flocks were kept in aviary multi-tier systems with two (n=3 farms) or three (n=8 farms) tiers, and the houses were divided within by wire fencing to create up to six separate sections with no more than 3000 birds in each. The hens were slaughtered at around 75-85 weeks of age on six farms and 85-95 weeks on four farms. On the one remaining farm, birds were killed on-farm to avoid transport to an abattoir, at around 92-102 weeks of age.

5.2.1 Indoor environment

On nine of the laying hen farms, litter quality was dry and flaky (although it was difficult to make a proper assessment on two farms due to a very thin layer of wood shavings). Moderately and severely deteriorated litter was observed in one of the five locations assessed per farm (otherwise dry and flaky) on each of the two remaining farms. Litter depth was scored as thin on three farms, average on four farms and thick on four farms. On three of the farms, whenever the bedding was considered too thick by the farmer or bird caretaker, some or all of the bedding was removed without replacement (to avoid floor eggs according to one farmer).

On the farms where pop-holes were open, the dust sheet test revealed no dust, little dust and a thin covering on one, five and one farm, respectively. Where pop-holes were closed, no dust, little dust, a thin covering and much dust, respectively, were observed on the remaining four farms. No birds were seen panting or huddling in any of the flocks.

Six of the farmers provided roughage (lucerne, silage, hay or straw bales, fodder carrots) year-round, while five of the farmers did so only when the birds had no outdoor access. Pecking stones, limestone blocks and/or seashells were provided as additional environment enrichment on six of the farms.

5.2.2 Health

Plumage damage (assessed according to Bilcík & Keeling (1999)) was especially prevalent and most severe on the breast and belly, and tail, which had median flock prevalence (min-max) of plumage damage score ≥3 per flock of 96 (84-100) % and 96 (72-100) %, respectively. Most birds were also observed to have moderate to severe plumage damage (score 2-4) to the wings, for which the median flock prevalence was 98 (94-100) %. Plumage damage to the head and neck, and back and rump, was in general less severe and varied more between flocks (see Paper III for details).

The median flock prevalence of dirty plumage was 71 (0-100) %. The majority of these hens (72%) had slightly dirty plumage and those with moderately and very dirty plumage were found predominantly on three of the farms.

Skin lesions were most severe and most common on the belly and cloaca, with a median prevalence of 4 (0-40) %. The affected birds were predominantly found in four of the flocks, in which the majority (97%) of the birds with lesions on the back and rump were also observed. There was a significant positive association between skin lesions and plumage damage on the back and rump (p<0.001), and between skin lesions on the belly and cloaca and plumage damage on the breast and belly (p<0.001). All birds with skin lesions also had moderate to severe plumage damage on the corresponding body part. Comb pecking wounds were observed in all flocks, with a median prevalence of 38 (14-58) %. Breast skin lesions were observed in all flocks, and the median flock prevalence was 57 (10-74) % (Figure 6).

Keel bone deviations were observed in all flocks. The median prevalence of deviations per flock was 67 (32-84) %, of which more than half (64%) had severe deviations. There was a significant positive association between keel bone deviations and breast skin lesions (p=0.02). The median number of birds per flock with a fracture was 1.5 (0-4).

The median flock prevalence of hens with hyperkeratosis involving minor and severe lesions was 35 (0-58) % and 33 (8-96) %, respectively (Figure 7). There was a significant positive association between hyperkeratosis and breast skin lesions (p<0.001). There was no significant effect of litter depth on the overall (minor and severe) prevalence of hyperkeratosis (p=0.65).

However, litter depth was associated with prevalence of severe hyperkeratosis (p=0.003), which was lower in flocks housed on a thick layer of litter.

Figure 6. Breast skin lesion (overlaying keel bone) in laying hen.

Figure 7. Severe hyperkeratosis on the metatarsal foot pad in laying hen.

The median prevalence of birds per flock with foot pad dermatitis and bumble foot was 10 (0-22) % and 3 (0-10) %, respectively. There was a significant positive association between foot pad dermatitis (including bumble foot) and breast skin lesions (p=0.03).

Birds missing one toe and/or claw) were observed in seven flocks, and the median prevalence (min-max) per flock was 3 (0-18) % (Figure 8).

Figure 8. Missing (left) and severely damaged toe (right) in laying hen.

5.2.3 Behaviour

During the continuous group behavioural observations, the most common behaviours observed (estimated percentage of the majority behaviour for each bird during five minutes) were standing (on average 37% of the birds) and foraging (36%). Comfort behaviours were observed in all flocks, although the number of observations varied between flocks, but aggressive behaviour or feather pecking was rarely or never observed. There was a significant effect of litter depth on the number of dust bathing events observed per farm (p=0.007), with more dust bathing events observed with increasing litter depth.

Behavioural observations at pop-holes were performed on eight of the laying hen farms. On the remaining three farms, the pop-holes were closed at the time of the farm visit due to unfavourable weather conditions, attacks by wild predators or loose hunting dogs. The most common behaviours observed at pop-holes were walking (going through), standing and foraging, for which the median number of observations per pop-hole was 12.5 (2-76), 8 (0-21) and 5 (0-21), respectively (see Paper III for details).

The majority (n=219) of the avoidance distance test trials performed in total (n=231) on all farms were unsuccessful (*i.e.* the birds distanced themselves before the observer could stop, turn and face a sitting hen). The successful trials (n=12) were performed on five of the farms, with a median distance (min-max) between the observer and a hen of 90 (20-150) cm. Of the successful trials, six were performed on one farm.

The median number of birds per farm approaching during the novel object test (n=4 trials per farm) was 2 (0-9). The median time for birds to approach (trials when no birds approached excluded), as well as for the first bird in each trial to approach, was 80 (10-120) seconds.

5.2.4 Free-range(ing)

The hens were normally provided with free-range access from around 19-24 weeks of age, unless pullets arrived on the farm during late autumn or winter, in which case the pop-holes were opened in the following spring. The laying hen flocks observed were first provided with free-range access at 19-25 weeks of age (7 flocks) or 40-48 weeks (4 flocks). The hens on all farms except one (on which birds sometimes had free-range access during winter in favourable weather conditions) normally had free-range access from around April-May (spring) to October-November (autumn), although access was strongly weather-dependent. During this period, the hens generally had access to the free-range area from around 06.00-08.00 h until approximately 21.00-24.00 h, although outdoor access from 01.00 to 17.00 h, from 08.00-09.00 to 18.00 h, from 10.30-11.30 h until around sunset, or 24 hours per day was also reported. Pop-holes were open for the birds to use the veranda during daylight hours year-round on the eight farms providing these.

The proportions of the free-range area per farm consisting of protective vegetation cover (*i.e.* trees, bushes or tall grass ≥50 cm) and of pasture are shown in Figure 9, together with any artificial shelters provided.

Seven of the observed free-range areas were completely enclosed, while the remaining four were equipped with a fence closest to the house only. Some farmers considered predation to be a minor issue, while others reported moderate to severe problems, especially with foxes and birds of prey, but also with mink (*Mustela lutreola*) and pine marten (*Martes martes*).

The maximum estimated proportion of hens free-ranging during farm visits was 1-13% on 10 of the farms and 56% on the one remaining farm. The majority of hens in most flocks were observed ranging within 20 m, but up to 75 m, from the house or veranda. All farmers except one agreed that different flocks display very large variation in terms of how much and how far they range, but that the majority of birds in most flocks normally range no farther than around 50-60 m from the house.

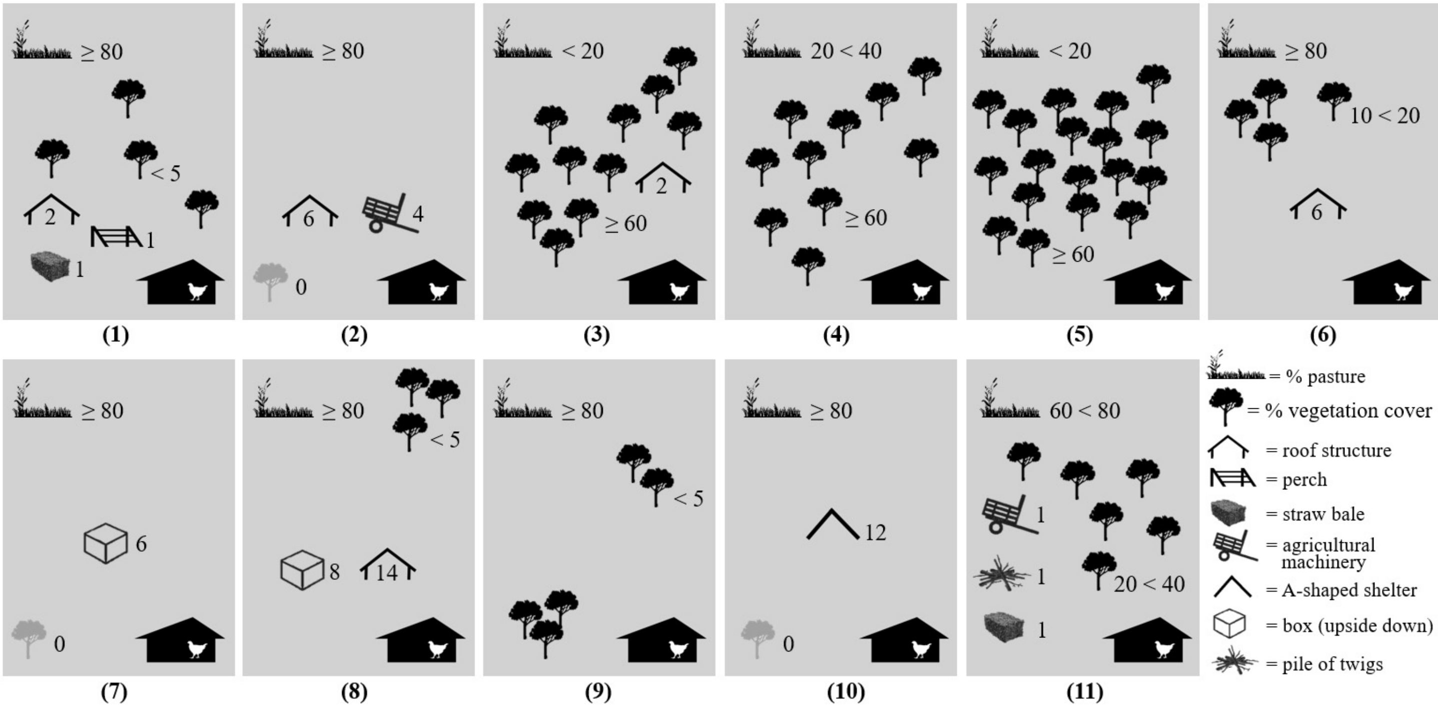


Figure 9. Schematic illustration (note: not to scale) of vegetation dispersion and artificial shelters in free-range areas on organic laying hen farms (n=11).

6. General discussion

While acknowledging that a comprehensive discussion about farm animal welfare requires *e.g.* economics, practicability and environmental factors to be taken into account, the following discussion revolves around animal welfare on organic poultry farms, as observed on the Swedish broiler and laying hen farms studied as well as in more general terms. Moreover, it should be emphasised that the studies which this thesis comprise covered only one part of the life of a broiler or laying hen. Hatching, rearing and slaughter involves important aspects to consider in an overall evaluation of animal welfare in poultry production, but were not included in this thesis.

6.1 Methodological considerations

The purpose of descriptive (or observational) studies is to collect information and provide a description of the present situation, in terms of *e.g.* health or other characteristics, in a population. Although conducted without any manipulation of the environment, descriptive studies are sometimes referred to as 'natural experiments', since there may be sufficient natural variation to allow for an epidemiological approach (Dawkins 2012). Epidemiology is the study of the distribution and determinants of *e.g.* diseases or disorders within a certain population, and such research provides knowledge about prevention and control of *e.g.* health-related problems. In order to establish cause and effect relationships and to identify risk factors, an epidemiological approach is required. Descriptive research may be used to demonstrate associations between different variables, to identify areas of interest for future research and to describe, as in this thesis, the present *e.g.* welfare situation on commercial poultry farms.

Twelve organic broiler farms in Sweden, all certified according to KRAV standards, were identified at the time of the study in 2018. Of these, one farmer declined when asked to participate and three were unsuccessfully contacted. To the best of our knowledge at the time, the eight farms visited represented two-thirds of all commercial organic broiler farms in Sweden. However, more recent statistics show that there were 18 organic broiler farms in Sweden in 2018 (Swedish Board of Agriculture, 2022a), and thus the farms participating in the study represented 44% of the total number.

The 11 laying hen farms participating in the study represented approximately 11% of the total number of organic laying hen farms in Sweden (Swedish Board of Agriculture, 2022a). Of the 98 commercial farms in Sweden at the time of the study in 2020, approximately 69% were certified according to KRAV standards (R. Dinwiddie at KRAV, personal communication on 11 August 2022). The median farm size of these KRAV-certified farms was 17 980 (1200-100 000) (R. Dinwiddie at KRAV, personal communication on 11 August 2022), which corresponds very well with that of the farms included in the laying hen study.

Although a reasonable sample to represent current organic broiler and egg production in Sweden, the low number of farms included in the studies made statistical analysis challenging and limited extrapolation of the results. For instance, in the broiler study, it was not possible to separate hybrid effects from the effects of other individual farm-related factors. For both broilers and laying hens, specific management routines and environmental determinants were difficult to analyse in relation to *e.g.* health scores. Despite the limitations in terms of statistical analysis and identification of factors that may improve or impair bird welfare, the results for Swedish broiler as well as laying hen farms can be considered to provide a solid basis for describing the present welfare situation, as intended.

A major advantage of on-farm studies is the relevance of the results for animal welfare in commercial production. On-farm research has its challenges, however, as it may involve thousands of animals of different origin and breed, and many different farmers and farms, on which control of conditions is difficult and variability is high (Dawkins 2012). For instance, data collection may not always be performed at the most suitable time in terms of study design, as farm visits must be planned according to *e.g.* farmer availability and preferences. Upon arrival at one farm in the laying hen study, the farmer did not consent to individual handling of the birds. On another three laying hen farms, the pop-holes were closed at the time of visit. Moreover, due to the challenges associated with obtaining complementary information retrospectively from farmers, there was some additional ‘missing information’ in the collected data.

Farm visits were limited to one day on each farm, due to practical constraints. Repeated observations, within flocks and in more than one flock per farm, would have enabled observations in a broader context, *e.g*. across flocks and in different weather conditions. Such a study design would have allowed for more profound conclusions in terms of *e.g*. behaviour, which is affected by time of day, and health, for which there might be a seasonal effect.

The broiler flocks were observed as late in the production cycle as possible, yet while the autumn weather still allowed the birds to have outdoor access. This resulted in some age variation between the flocks. In contrast, the laying hen farm visits were planned so that the flocks were around the same age, and thus observations were performed during different seasons, which could have had an effect on both health and behavioural observations.

Organic broiler production in Sweden is very small, but the proportion of organic laying hen farms is one of the highest among EU countries (Augère-Granier 2019). The large variation between organic animal farms has been emphasised previously (Van de Weerd *et al.* 2009), and hence there are certainly limitations regarding the extent to which the present results can be extrapolated across country borders. For instance, as organic poultry production in Sweden must conform to the seasonal constraints of northern hemisphere weather, the birds generally do not have outdoor access during winter. Nevertheless, the findings from the present studies align to a large extent with findings in previous on-farm research in terms of *e.g*. some health aspects and free-ranging behaviour, indicating that the results should suffice for a certain degree of extrapolation to organic poultry production in other EU countries.

6.2 Animal welfare on organic poultry farms in Sweden

Below follows a discussion of the results in terms of animal welfare as comprising health, naturalness and affective states. Again, it is important to emphasise that these three aspects are to some extent overlapping and interconnected, and several of the findings discussed may be of importance to all three. The main results from the broiler and laying hen studies are discussed in tandem.

6.2.1 Health (biological functioning)

Many welfare indicators reflecting an animal's health status and biological functioning are relatively easy to measure and quantify. However, it is more difficult to determine when, and to what extent, any impairment such as a small or large injury or a particular disease, will reduce welfare (Fraser *et al.* 1997).

Plumage damage is considered a good indicator of severe feather pecking (Bilcík & Keeling 1999). No severe feather pecking was observed directly in the laying hen study, likely due to the limited time and a sampling method less suited for capture of infrequent behaviours. However, the prevalence and magnitude of plumage damage suggest that severe feather pecking occurred in all laying hen flocks. Although differences in scoring method and assessment criteria, presentation of results and age of the hens complicates the comparison with findings in other on-farm studies of organic laying hens, marked plumage damage has been reported previously in a number of epidemiological studies (*e.g.* Bestman & Wagenaar (2014); Bestman *et al.* (2017); Grafl *et al.* (2017)). This abnormal behaviour among hens is recognised as an indication of poor adaptation and might represent an accumulation of various stressors, resulting in excessive levels with which the hen can no longer cope (Cronin & Glatz 2021). The subsequent plumage damage has been shown to impair normal *e.g.* thermoregulatory functions and to reduce egg production (Glatz 2001).

Bald patches and blood from severe feather pecking can contribute to the development of tissue pecking (cannibalism), another welfare issue in loose-housing systems, which can result in high mortality rates (Cronin & Glatz 2021). There was indeed a significant association between plumage damage and **skin lesions** on the corresponding body part in the laying hen study. The median flock prevalence of 4 (0-40) % of skin lesions on the belly and cloaca of laying hens indicates that tissue pecking occurred to some extent in some of the flocks, but not all, in agreement with previous findings in organic or free-range laying hens (Bestman & Wagenaar 2014; Bestman *et al.* 2017; Grafl *et al.* 2017).

Apart from damage, fouling of the plumage can also reduce its insulating properties (Ward *et al.* 2001). **Dirty plumage** was observed in all laying hen flocks except one and in all broiler flocks, although the prevalence varied greatly. The broiler flocks were all visited during autumn, as were the three laying hen flocks in which the majority of hens with moderately and severely dirty plumage were observed, when there is normally more precipitation and muddy ground conditions in Sweden. Thus, the weather conditions to which free-ranging poultry were exposed may have contributed to the variation observed between flocks. Such outdoor weather conditions might also result in poor litter quality indoors, as reported by several of the farmers in the present studies, which could cause fouling of the plumage.

Plumage cleanliness in broilers decreased significantly with increasing body weight, in agreement with previous observations (Rauch *et al.* 2017; Stadig *et al.* 2017). Birds spending more time sitting down may be more susceptible to fouling from conspecifics, as well as become dirty from contact with the litter (Wallenbeck *et al.* 2016). Poor litter quality may also be a consequence of increased faecal liquid content (diarrhoea), which was observed predominantly in three of the broiler flocks studied. However, litter quality and plumage condition were not noticeably deteriorated in these particular flocks. Other explanations for dirty plumage include faecal matter from birds *e.g.* perching above.

Keel bone deviations were observed in all laying hen flocks. The average prevalence per flock (65%) is similar to the 66% previously reported for Swedish organic laying hens in aviary systems, although both deviations >0.5 cm and fractures were included in that figure (Jung *et al.* 2019). However, the average prevalence (44.5%) across all flocks in the different European countries included in the aforementioned study (Jung *et al.* 2019), was lower than in the present laying hen study. The reason might be the relatively higher flock age in the latter, as the prevalence of deviations has been shown to increase with age (Heerkens *et al.* 2016a). Keel bone deviations are believed to result from prolonged mechanical pressure during perching (Heerkens *et al.* 2016a) and have been found to appear especially during peak production (Gebhardt-Henrich & Fröhlich 2015). Due to the attachment of the breast muscles to the keel bone, severe deviations may impair normal movement (Tauson *et al.* 2006) and increase the risk of keel bone fractures as a result of unequal bone loading during *e.g.* wing-flapping and balance manoeuvres (Harlander-Matauschek *et al.* 2015). Thus, considering the high prevalence of severe keel bone deviations, which have previously been associated with keel bone fractures (Thøfner *et al.* 2021), the relatively low prevalence of fractures found in the present laying hens study is likely an underestimation.

The mean prevalence of **keel bone fractures** per flock found in the laying hen study (3.4%) was considerably lower than the average range (11.6-87.5%) reported previously for organic and free-range laying hens (Richards *et al.* 2012; Riber & Hinrichsen 2016; Thøfner *et al.* 2021). This discrepancy may be explained by the limitations associated with using external palpation for detection of fractures (Thøfner *et al.* 2021). Trauma (as hens collide with the housing interior in non-cage systems) has long been one of the predominant explanations for keel bone fractures, although recently contradicted by novel findings (Thøfner *et al.* 2020). More recently, early onset of lay and production of large eggs have been associated with an increased risk of keel bone fractures (Thøfner *et al.* 2021). Keel bone fractures have been shown to reduce mobility (Nasr *et al.* 2012), and due to the attachment of the breast muscles to the keel bone, it has also been suggested that such damages may also impair respiratory movements (Riber *et al.* 2018a).

Breast skin lesions were observed in half of the laying hens examined, and in all flocks. These lesions were predominantly found in the middle or towards the cranial part of the keel bone, appearing as brown or black scabs and/or focal thickening and reddening of the skin. Such lesions have rarely been described previously in laying hens, although one experimental study found "breast blisters" (not described in detail) and redness in up to 25% of loose-housed hens (Steenfeldt & Nielsen 2015). Breast blisters may refer to enlarged sternal bursas, which can result from *e.g.* prolonged friction or pressure, especially in individuals with poor feather cover (Miner & Smart 1975). The pathogenesis of the skin lesions observed in the present laying hen study is unknown, as are the ensuing welfare implications. There was a significant association between these lesions and keel bone deviations, contradicting previous findings (Gunnarsson *et al.* 1995). Considering that keel bone deviations are believed to result from mechanical pressure during perching, the association observed in the present laying hen study may indicate that friction on the skin during *e.g.* perching contributes to the development of such skin lesions, especially considering the poor feather cover on the breast and belly (Miner & Smart 1975) observed in the present study.

Around two-thirds (64%) of the broilers examined in the broiler study showed minor to moderate **gait abnormalities**, which is similar to the prevalence found in other studies of slower-growing hybrids on commercial farms (Baxter *et al.* 2021), or somewhat higher (Tahamtani *et al.* 2018). Consistent with those previous studies, no birds were observed to have severe walking impairments. Considering that poor leg health was one of the main reasons for culling reported by the farmers in the broiler study, especially towards the end of a production cycle, the absence of severely lame birds might indicate that these individuals were appropriately culled.

There are a number of different underlying reasons for impaired gait and lameness in broilers, including skeletal deformities, bone weakness and unbalanced body conformation (Hartcher & Lum 2020). Rapid growth rate and high body weight have been identified as primary risk factors (Kestin *et al.* 2001; Rauch *et al.* 2017). In the broiler study, gait scores in flocks with relatively lower average body weight were significantly lower (better) than those in flocks with higher average body weight. It should be noted that low body weight uniformity was found in all flocks, *i.e.* within flocks there was quite large variation in body weight between individuals. Compromised mobility may not only impede access to resources such as feed and water (Weeks *et al.* 2000), but may also reduce activity levels, further aggravating compromised leg health (Hartcher & Lum 2020).

Extended periods of sitting down can also result in **hock burns** in broilers (Kjaer *et al.* 2006). In the broiler study, hock burns were significantly correlated with higher body weight, as observed previously (Kjaer *et al.* 2006), although minor lesions only were found. Similarly, the majority (92%) of all chickens observed with **foot pad dermatitis** in broiler study had minor lesions. No bird was observed to have severe lesions, contradicting previous findings in slower-growing broilers on commercial farms (Pagazaurtundua & Warriss 2006; Gouveia *et al.* 2009; Lund *et al.* 2017). Different hybrids (Rauch *et al.* 2017), litter quality (Jong *et al.* 2014) and outdoor ground conditions (Sarica *et al.* 2014) may explain these discrepancies.

The average prevalence (11.0%) of foot pad dermatitis per laying hen flock was within the quite wide span (4.8-41.2%) previously reported as foot pad lesions in organic laying hens, and the average prevalence of bumble foot (3%) was similar to earlier findings for free-range flocks (Bestman & Wagenaar 2014; Heerkens *et al.* 2016b; Riber & Hinrichsen 2016; Grafl *et al.* 2017; Jung *et al.* 2020). Foot pad dermatitis, *i.e.* damage to the integumentary system of the feet, not only poses a risk of secondary infections, as seen with bumblefoot in laying hens (Heidemann Olsen *et al.* 2018), but has also been associated with impaired walking ability in broilers (Opengart *et al.* 2018).

The risk of bacterial colonisation may also arise following secondary erosions in hyperkeratotic foot pads (Weitzenbürger *et al.* 2006). **Hyperkeratosis**, *i.e.* thickening of the skin, was observed in all laying hen flocks. The prevalence of excessive hyperkeratosis was lower in flocks housed on a thick layer of litter, perhaps because this prevented contact with the cement floor while *e.g.* ground scratching. These hens may also have been more motivated to spend time in the litter area, and thus less time on the slatted floor or on perches. It has been suggested that hyperkeratosis may result from prolonged excessive mechanical pressure exerted on the foot pads (Weitzenbürger *et al.* 2006), as during perching. The average prevalence of hyperkeratosis (71.5%) found in the laying hen study was markedly higher than previously reported (33.5%) for free-range flocks (Heerkens *et al.* 2016b). Outdoor access was associated with lower prevalence of hyperkeratosis in the aforementioned study, but free-range use as well as local terrain and ground conditions are likely to determine how outdoor access influences foot health in poultry (Heerkens *et al.* 2016b).

Two laying hens were found dead and one was found alive but injured, with their toes caught in the housing system interior, on three different farms (unpublished data). Such accidents, which have been reported previously by organic farmers in Sweden (Berg 2001), were most likely the reason for the **missing toes and/or claws** observed in seven of 10 flocks in the laying hen study, with up to nine out of 50 sampled individuals affected. The median prevalence per flock (3%) was similar to that observed in a previous study of loose-housed laying hens on commercial farms (Riber & Hinrichsen 2016). The observations of such lesions put emphasis on an important risk of injury and death (Gebhardt-Henrich & Fröhlich 2015) in modern commercial housing systems for laying hens.

6.2.2 Naturalness (natural living)

Due to the process of domestication and intense genetic selection in poultry production, natural life for the domestic chicken is a man-made concept (Vaarst & Alrøe 2012). The absence of some behaviours observed in the wild does not necessarily indicate poor welfare in captivity (Hemsworth & Edwards 2021), and the imperative elements of a natural environment for the domestic chicken may not be synonymous with the jungle (Vaarst & Alrøe 2012). Nevertheless, research has generated great knowledge of highly motivated species-specific behaviours in the domestic chicken. Allowing for performance of such behaviours by providing an environment similar to that to which chickens were originally adapted may be an important way to improve animal welfare (Špinka 2006).

Although **outdoor access** *per se* provides a more natural environment for laying hens and broilers, the free-range areas observed in the present studies did not always include the elements that may contribute to a more natural environment, *i.e.* protective vegetation cover (Larsen *et al.* 2017). The majority of the outdoor areas for broilers consisted mainly of pasture, with little or no vegetation cover, and when protective vegetation was present it was typically restricted to a particular area of the range. Trees and bushes covered one-fifth or more of the entire free-range area on two broiler farms only. Similarly, the free-range area assessed (within 200-250 m from the hen house) contained no or very little protective vegetation cover on half of the laying hen farms. Although various types of trees had been planted on four farms, the area in front of the hen house comprised at least 80% pasture on the majority of laying hen farms, whereas the proportion of pasture was less than 20% on two farms only. Numerous studies show that vegetation cover is important to encourage birds onto and farther out into the range (*e.g.* Dawkins *et al.* (2003); Larsen *et al.* (2017); Stadig *et al.* (2017); De Koning *et al.* (2018)). Similarly, the protection offered by artificial shelters may increase free-ranging in laying hens and broilers (Zeltner & Hirt 2003; Gilani *et al.* 2014; Fanatico *et al.* 2016). Although such artificial shelters were provided in various forms, sizes and numbers on the farms included in the present studies, the total overhead protective area was generally limited.

With outdoor access comes the inevitable risk of **predators** (Bestman & Bikker-Ouwejan 2020). The majority of farmers reported some issues with predators and many described moderate and severe problems with especially foxes and birds of prey. Sufficient protection against aerial predators may be difficult to achieve, but ground predators can be successfully kept out by appropriate fencing, as reported by some of the farmers in the present studies. However, on four laying hen farms and one broiler farm, the outdoor area was equipped with a fence closest to the house only. Moreover, fences were slacking considerably on two broiler farms. It may not be possible to eliminate the risk of predators completely, and a certain level of predator fear may be considered adaptive in free-range poultry (Lindholm *et al.* 2016). Nevertheless, appropriate fencing and sufficient protective cover should be provided to reduce exposure to predators, and the associated fear of these.

Multi-tier systems for laying hens, as observed on all farms in the laying hen study, allow for **perching** high above the ground as well as in synchrony within the flock. The broiler flocks studied were provided with a variety of environmental enrichment items intended to allow birds to sit in an elevated position, and some of these (*e.g.* perches, a cart and straw bales) were particularly well used by the chickens. However, the available space on such items was generally low on all farms, and for instance 0.5 cm perch per broiler towards the end of the production cycle on one farm. The current requirement for 5 cm perch and/or 25 cm^2 raised sitting area per broiler was not in place at the time of the study (EU 2020/464). Sufficient perch length and/or sitting area are important to enable all birds to perch (Nielsen 2004), but research concerning the number of enrichment items required in relation to flock size is limited (Riber *et al.* 2018b).

Although the upper limit imposed in terms of flock size on organic poultry farms may not be primarily due to animal welfare considerations (Padel *et al.* 2004), it is nevertheless an important aspect to consider with regard to animal welfare. Normal **social behaviour** in wild jungle fowl (Collias *et al.* 1966) as well as in the domestic chicken (Rushen 1982) involve establishment of a pecking order within a small flock. However, no such social hierarchy based on individual recognition of flock mates is possible in the very large flocks normally found on commercial farms (Estevez *et al.* 1997; Hughes *et al.* 1997; D'Eath & Keeling 2003). It has been suggested that alternative social strategies, which reduce agonistic interactions between individuals that become more tolerant to unfamiliar flock mates, are adopted in large flocks (Estevez *et al.* 1997; D'Eath & Keeling 2003), such as those found on the broiler as well as laying hen farms observed in the present studies.

6.2.3 Affective state (subjective experience)

Previous discussions about animal behaviour have largely revolved around the concept of 'behavioural needs' and whether animals suffer (and to what extent) when deprived of the opportunity to meet these needs (Dawkins 1988). This discussion has evolved to include the concept of 'positive affective engagement', *i.e.* the notion that animals may experience a range of positive affects when they have the opportunity to respond actively to motivations to engage in rewarding behaviours (Mellor 2015a). Behavioural restrictions, whether they are associated with negative affects or not, may thus represent a privation of opportunities for animals to experience a range of positive emotions (Mellor 2015a).

Depending on the type and severity of a disease, physical injury or any other signs of suboptimal biological functioning, different levels of **pain** and other negative affective states such as **discomfort** or fear may arise (Hemsworth *et al.* 2015).

It is unclear whether keel bone deviations or the development of these deviations are painful (Riber *et al.* 2018a), whereas keel bone fractures have been associated with some behavioural indicators of pain (Nasr *et al.* 2012; Gebhardt-Henrich & Fröhlich 2015). In the broiler study, 23% of the birds were observed with moderate gait impairments, which has previously been associated with pain (Caplen *et al.* 2013). Although about one-third (36%) of the broilers walked without any anomalies, the remaining 41% showed slight or some gait abnormalities, which has more recently been suggested may also be associated with pain (Riber *et al.* 2021). Physiological indicators (Sherlock *et al.* 2012), histological findings (Michel *et al.* 2012) and behavioural observations (Hothersall *et al.* 2016) make evident that foot pad dermatitis is a painful condition. Bumblefoot was found in most laying hen flocks studied, but the majority of affected broilers showed minor lesions, which are likely to induce no or slight pain (Michel *et al.* 2012). The severe tissue damage seen in the laying hens missing a toe and/or a claw would have been associated with acute pain (Gentle 1992), and a risk of secondary infections and more chronic pain.

The forceful pecks and the pulling of feathers seen during **severe feather pecking** is painful for the recipient bird (Gentle & Hunter 1991) and not only stressful for the victim but also for other birds in the flock (Jones *et al.* 2004). Stress, especially the accumulation of various stressors, has been identified as an important factor predisposing hens to the development of feather pecking behaviour (see Cronin & Glatz (2021) for a review). Although studies investigating this link have generated inconclusive results (Cronin & Glatz 2021), some findings indicate that hens more or less likely to become feather peckers may differ in terms of behavioural coping styles and physiological and neuroendocrine stress responses (Korte *et al.* 1997; Rodenburg *et al.* 2004). How this relates to affective states in the birds warrants further research (Pichová *et al.* 2021).

Impaired mobility, due to *e.g*. physical injury and any associated pain, can by extension generate negative affective states due to the inability to access resources or perform highly motivated behaviours. Laying hens with keel bone fractures show reduced use of pop-holes (Richards *et al.* 2012), reluctance to access perches and longer latency to leave perches (Nasr *et al.* 2012). Severe keel bone deviations have been suggested to impair normal movement (Tauson *et al.* 2006). It has also been suggested that bumblefoot can cause discomfort and physical difficulties in maintaining good grip while perching (Gebhardt-Henrich & Fröhlich 2015). Whether severe hyperkeratosis impairs perching in a similar manner, due to physical distortions of the foot pads, remains to be determined. Compared with non-lame broilers, lame individuals perform more activities while sitting rather than standing (Weeks *et al.* 2000), and impaired mobility may hamper *e.g.* access to perches (Malchow *et al.* 2019). Also minor gait abnormalities have recently been linked to inactivity, more sitting while feeding, less time spent performing comfort behaviours and foraging, and reduced likelihood to perch (Riber *et al.* 2021).

Notwithstanding these physical considerations, the laying hens in the laying hen study were provided with the opportunity to respond to their strong motivation to perch (Olsson & Keeling 2000). Besides sitting on the environmental enrichment items provided for the purpose, the broilers were also observed **perching** on feed and water lines, and on the rim of plastic troughs or pallet collars primarily intended for dust bathing, demonstrating both physical ability and motivation to perch (Malchow *et al.* 2019). However, due to the limited available perch length and sitting area per bird, only some individuals were able to engage in perching at any one time.

Outdoor access may provide a more stimulus-rich environment for exploration and foraging behaviours (Campbell *et al.* 2017; Thuy Diep *et al.*

2018). The general lack of protective cover in the outdoor areas observed on several farms might have discouraged the birds from entering the free-range area, as demonstrated previously (Bestman & Wagenaar 2003; Dawkins *et al.* 2003; Gilani *et al.* 2014; Pettersson *et al.* 2017; Stadig *et al.* 2017). The majority of broilers and laying hens outside were mainly observed ranging close to the house, in agreement with findings in other on-farm studies (Dawkins *et al.* 2003; Zeltner & Hirt 2003; Chielo *et al.* 2016; Fanatico *et al.* 2016). Although it should be noted that outdoor observations in the present studies were limited to no more than twice during one day on each farm, these observations were generally in agreement with farmers' accounts of free-ranging behaviour. Previous research indicates that more fearful hens are less prone to go outside (Campbell *et al.* 2016). It has also been suggested that broilers that remain close to the house are more fearful of predators (Lindholm *et al.* 2016; Stadig *et al.* 2017), which might indeed be a legitimate behaviour in the event of an actual predator attack (Bestman & Bikker-Ouwejan 2020).

Fear of predators may not be limited to the outdoor area, as humans may be perceived as such by domestic farm animals (Hemsworth & Coleman 2011). The strong avoidance reactions observed in almost all broiler and laying hen flocks during the avoidance distance tests in the present studies are commonly considered to reflect a relatively high **fearfulness of humans** (Graml *et al*. 2008). However, in the present studies, it is possible that the avoidance reactions represented more specifically a fearfulness of an unfamiliar human wearing unfamiliar clothing (Barnett *et al.* 1993; Bryan Jones 1994). Since shelter and protective cover are important in allowing chickens to hide from predators, not only in the outdoor environment but also indoors (Newberry & Shackleton 1997), the broilers in particular might have perceived themselves as highly exposed considering their open and rather barren indoor environment.

Positive **social interactions** are in general considered to promote positive welfare and higher quality of life (McMillan 2000; Mellor 2016a). Research to date on social interactions in domestic chickens has focused on reducing adverse behaviours, while less is known about the potential benefits of positive social behaviours and social support (Rault 2012). A preference for familiar birds over unfamiliar birds has been demonstrated in domestic chickens (Bradshaw 1992; Väisänen & Jensen 2004), although they seem to quickly become accustomed to unfamiliar birds (Bradshaw 1992). No evidence of specific preferential associations between individual laying hens in small groups was found in another experimental study (Abeyesinghe *et al.* 2013). Thus the welfare implications of frequent and recurrent encounters with unfamiliar conspecifics, and of not being able to establish a pecking order in large flocks, are unclear (D'Eath & Keeling 2003; Appleby *et al.* 2004).

6.3 The perks of being an organic chicken

Organic agriculture should provide everyone involved with a good quality of life, according to the Principle of Fairness (Box 2). Outdoor access, lower stocking density, use of slower-growing broilers, provision of raised sitting areas, natural light and roughage, and a ban on beak trimming are some of the most prominent features of organic poultry production relevant for animal welfare under current EU regulations (EU 2018/848; EU 2020/464). As such, they represent the outcome of what is deemed important according to organic values and what is considered feasible at farm level within the current production context (Padel *et al.* 2004; Vaarst *et al.* 2004).

Environmental enrichment may not only provide perching opportunities for broilers, but can also *e.g.* enhance leg health (Kaukonen *et al.* 2017) and improve resting (Ventura *et al.* 2012). Hence, raised sitting areas have the potential to generate a range of pleasant experiences and reduce certain unpleasant ones. Similarly, outdoor access has the potential to improve welfare not only through the positive affective states associated with foraging and exploration, but it may also decrease negative emotions, as free-ranging has been shown to improve *e.g.* gait in broilers (Taylor *et al.* 2020) and reduce feather pecking in laying hens (Lambton *et al.* 2010; Bestman & Wagenaar 2014; Bestman *et al.* 2017). Outdoor access has been correlated to better foot health in both broilers and laying hens (Gouveia *et al.* 2009; Heerkens *et al.* 2016b), but a correlation to impaired foot health may arise following heavy precipitation and moist ground conditions (Sarica *et al.* 2014). Free-ranging may also reduce poultry welfare considering the risk of predators and disease transmission through contact with wildlife. Hence, appropriate fencing and biosecurity measures are important to counteract such risks (Bonnefous *et al.* 2022). Notwithstanding these perils, the emphasis on opportunities to perform natural behaviours in organic standards may improve bird welfare by promoting pleasant experiences, rather than merely avoiding unpleasant ones, which is consistent with the concept of positive animal welfare (Špinka 2006; Mellor 2015b). However, the content of the organic standards must transfer all the way to the farm in order to influence poultry welfare in practice, and not only in theory (Sundrum 2001). For raised sitting areas to increase the quality of life for broilers, sufficient amounts are required, as an example. Similarly, if the free-range area is not suitable for the purpose, it may do little in terms enhancing welfare. In fact, a free-range area without appropriate shelter could generate fear and other negative affective states in broilers and laying hens, as well as increase the risk of predation. Not only does this have consequences for animal welfare, but such discrepancies between organic standards and farm practices also have implications for the certification of organic products, which provides customer assurance (Padel *et al.* 2004).

The results from present as well as previous studies (*e.g*. Van de Weerd *et al.* (2009); Jung *et al.* (2020)) show that important welfare issues can be found on organic poultry farms. It must be emphasised that these problems are not inherent to organic production, but also occur in non-organic systems, as they relate to housing, management and genetic factors intrinsic to modern commercial poultry production (Van de Weerd *et al.* 2009).

The transition from fast-growing to more slower-growing broilers, on organic and non-organic farms, has resulted in notable welfare improvements in terms of *e.g*. leg health (Dixon 2020; Baxter *et al.* 2021; Dawson *et al.* 2021). Nevertheless, walking impairments and lameness remain an issue also among the more slower-growing hybrids, as observed in the present broiler study and in previous on-farm studies (Tahamtani *et al.* 2018; Baxter *et al.* 2021). 'Slow-growing' is a relative concept and additional welfare benefits may derive from using hybrids with even slower growth rates (Castellini *et al.* 2016).

The laying hen hybrids used on organic farms are the same as those used in non-organic commercial egg production (Fernyhough *et al.* 2020). Welfare issues associated with selective breeding for high egg production and early onset of lay, such as keel bone fractures, are thus also commonly seen on organic farms (Jung *et al.* 2019; Thøfner *et al.* 2021). Although there is a genetic component associated also with the development of severe feather pecking (Rodenburg *et al.* 2013), housing and management factors are acknowledged as imperative for alleviating this multi-factor problem (Jung & Knierim 2018). Insufficient dietary protein (in particular the amino acids methionine and cysteine) is a risk factor specific to organic egg production due to the ban on use of synthetic amino acids (van Krimpen *et al.* 2016). Other features that distinguish organic egg production from some other loose-housing systems, such as the provision of roughage (Steenfeldt *et al.* 2007) and outdoor access (Lambton *et al.* 2010), may have a protective effect against severe feather pecking. However, benefits derive not from provision of a free-range area, but from use of that area (Bestman & Wagenaar 2003). Moreover, although not included in the present laying hen study, rearing conditions are imperative for the welfare of laying hens during lay and have been shown to influence the subsequent development of severe feather pecking (Bestman *et al.* 2009; Lambton *et al.* 2010).

Some of the main features of organic poultry production, studied in this thesis, may provide opportunities for pleasant experiences as well as reduce unpleasant ones, thus promoting a *good* quality of life for broilers and laying hens (Yeates 2011). However, there is room for improvement in terms of both the indoor and outdoor environment in order to provide better opportunity for such positive experiences. Moreover, to further improve their quality of life, major welfare challenges such as keel bone damage and severe feather pecking, need to be overcome.

When managing animals in commercial production, economics, practicability and environmental aspects must inevitably be taken into account, in addition to animal welfare (Padel *et al.* 2004). Thus, although high animal welfare standards are embedded in each of the four principles of organic agriculture (Box 3), the magnitude of any such welfare improvements possible at farm level within the context of modern commercial poultry production may be limited (Appleby 2019). For instance, while a number of positive welfare consequences have been demonstrated at stocking densities around 21 kg/m^2 (Table 2) in comparison with smaller space allowances for broilers (Ventura *et al.* 2010; Ventura *et al.* 2012; Sun *et al.* 2013), more pronounced welfare benefits may come from reducing the stocking density further (Buijs *et al.* 2009; Buijs *et al.* 2010). However, as long as currently accepted baseline animal welfare standards in intensive poultry production serve as the reference point, attempts to enhance animal welfare in organic poultry production may fall short (Mellor 2015b).

6.3.1 Conventionalisation

The marked transformations that organic farming has undergone since the pioneering work in the early 1900's have led to concerns about whether modern organic agriculture is still in agreement with the ethical principles of the movement (Padel 2007). Although change over time has been inevitable in order for organic agriculture to persevere, the importance of allowing such development to be guided by the principles of organic farming has been emphasised (Baars *et al.* 2004). The adoption of non-organic farming methods within organic production has been referred to as 'conventionalisation' of organic farming. More precisely, it has been described as the implementation of farming practices that comply with standards and regulations, but not with the organic principles (Darnhofer *et al.* 2009). Such practices may involve *e.g.* inadequate animal housing conditions, limited or hampered opportunities to perform highly motivated species-specific behaviours or too high production intensity, which ultimately might undermine one or several of the principles of organic agriculture.

The use of breeds that are not appropriate for organic farming systems (such as the high-producing laying hen hybrids used also in non-organic systems), high incidence of certain health issues (*e.g.* keel bone damage and gait impairments), abnormal behaviours (*e.g.* feather pecking) and limited provision of structural elements in the indoor environment (*e.g.* raised sitting areas for broilers) and outdoor environment (*e.g.* vegetation cover or artificial shelters) have been proposed as 'indicators' of conventionalisation (Darnhofer *et al.* 2009). Some of these may relate to management practices at farm level (Fraser 2014), as was evident from the large variation between the different farms in the present laying hen and broiler study, in terms of *e.g.* practical efforts to make the birds range more and farther out or to protect them from predators. Provision of environmental enrichments, as well as foraging and dust bathing substrates, and the time spent with the flock on a daily basis, may also differ between individual farmers, as observed on both the broiler and laying hen farms. However, appropriate management practices can only do so much for animal welfare (Fraser 2014). Other important aspects, such as genetics and certain features of commercial housing systems, may be inaccessible to the individual farmer and difficult to influence on farm level.

Structural changes *per se* may not indicate conventionalisation (Darnhofer *et al.* 2009), and the relationship between farm size and animal welfare is complex (Robbins *et al.* 2016), but the transition towards farm expansion and larger flocks in organic poultry production is not without consequences for bird welfare. First, the feasibility and time allocated for the care of individual animals is reduced when a flock comprises several thousand birds. Second, other aspects of importance for animal welfare may be indirectly affected. Although mere visual contact may be enough to reduce fearfulness of humans in birds (Jones 1993), interactions are limited when the human-animal ratio is very high (Rushen *et al.* 1999). Moreover, a negative correlation between flock size and outdoor use has been demonstrated (Gilani *et al.* 2014; Chielo *et al.* 2016), and it may be difficult to provide sufficient shelter in the large outdoor areas accompanying large flocks, or to equip these with protection against aerial predators. Third, keeping very large flocks might amplify the perils often identified as the main drawbacks of free-range poultry production. Outdoor access as a source of intestinal parasites is especially so when the distribution of birds in the range is poor, as when most of the flock range close to the house only (Thapa *et al.* 2015). Notwithstanding the risk of infectious disease transmission through contact with wildlife, the welfare consequences (in terms of number of affected animals) are obviously greater in a flock or on a farm comprising tens of thousands of birds. Hence, the discussion about the welfare risks associated with free-ranging should not be limited to outdoor access, but should consider also the risks associated with housing very large flocks (Barnes & Glass 2018). Fourth, human psychology and behavioural research has shown that our empathy and willingness to help decreases as the number of people in need increases, an effect known as 'psychic numbing' and 'compassion fade' (Fetherstonhaugh *et al.* 1997; Butts *et al.* 2019). In large poultry flocks there is a corresponding 'loss of singularity' when welfare is evaluated on a flock basis, rather than an individual basis (Harfeld *et al.* 2016).

6.3.2 Improved welfare, yet another human intervention?

Genetic selection in commercial poultry production has, and may in the future, not only been employed to increase productivity but also to address certain welfare issues (Underwood *et al.* 2021). Increased bone strength, better plumage condition, resistance to disease and improved free-ranging have been suggested as future breeding goals to improve laying hen welfare

(Fernyhough *et al.* 2020; Underwood *et al.* 2021). However, there are ethical considerations associated with modifying animals and adapting them to the environment which humans provide, as opposed to the other way around (Christiansen & Sandøe 2000), even when the intention is to improve the animals' quality of life (Bovenkerk 2020). There have been considerable welfare improvements through genetic selection for reduced growth rate in broilers, but more slower-growing hybrids are nonetheless, like their fast-growing precursor, the outcome of deliberate human intervention to modify animals that better suit current production systems. Thus, although not within the scope of this thesis, the discussion about genetic selection of animals goes beyond animal welfare to also encompass the moral considerations of altering animals for human purposes (Bovenkerk 2020).

6.4 How much research is enough research?

There is hitherto a substantial amount of research concerned with the assessment of animal welfare in different commercial poultry production systems (*e.g*. Pagazaurtundua & Warriss (2006); Sherwin *et al.* (2010); Grafl *et al.* (2017); Tahamtani *et al.* (2018)). Standing on their own, such studies have provided important information about the welfare situation in commercial production at a certain point in time, and about welfare issues that need to be addressed in the future. Combined, as part of a timeline, these studies also enable the evaluation of animal welfare in poultry production over time. The present studies add to this research timeline by providing important knowledge about the welfare situation in organic and loose-housing poultry production systems.

During recent decades, an extensive amount of research has been undertaken to increase our understanding and improve the welfare of the domestic chicken. The accumulated knowledge of *e.g*. health, physiology and behaviour deriving from these studies has contributed to significant welfare improvements over time in commercial poultry production. The ban on battery cages and introduction of enriched cages, and the subsequent transition towards loose housing systems for laying hens is one example, as is the introduction of more slower-growing broiler hybrids.

The rear view mirror could however reveal a somewhat different perspective. Notwithstanding the aforementioned welfare improvements to which scientific research has contributed to date, important welfare issues remain unresolved within modern poultry production despite efforts to alleviate these. For instance, feather pecking in laying hens has been studied for more than a century, but is still a major problem in non-cage systems (Cronin & Glatz 2021). Studies on keel bone damage date back at least three decades (Abrahamsson & Tauson 1993) but a considerable amount of research has yielded no solution within the current commercial egg production (Riber *et al.* 2018a). Although leg and foot health in broilers have improved over time, these issues still require more research for further welfare improvements (Tahamtani *et al.* 2018). Similarly, the importance of shelter in free-range areas for poultry has been studied for more than 25 years (Hofner & Folsch 1997), and is still investigated to date (De Koning *et al.* 2018).

The successful transfer of animal welfare research results to commercial production is an intricate process, involving various stakeholders as well as other factors such as economics, feasibility and production efficiency (Appleby 2019). Potential solutions for the main unresolved animal welfare issues may not only be difficult to find within current production systems, but might also be incompatible with other interests besides improving animal welfare. Thus, the implementation of relevant animal welfare research findings to enhance farm animal welfare is not necessarily restricted by lack of knowledge (ultimately requiring more research), but by the boundaries imposed by current production systems. Nonetheless, 'more research is needed' is a common conclusion in animal welfare research, and while more research is indeed being undertaken, severe welfare concerns persist in commercial poultry production. Hence, embedded within animal welfare research is the ethical question of whether we get an unlimited number of attempts to solve the same problems and investigate the same issues, without profoundly altering the background of the research questions? Animal welfare researchers may contribute to this discussion by considering whether the research at hand is sufficient to reveal any prospective solutions within a particular production system, to meet current animal welfare standards while also taking other factors into account. Some argue that animal welfare researchers ought to reflect on their results within the broader ethical context in which the issue under study belongs (Sandøe *et al.* 2003). One way of doing so might be to consider the input (research and current knowledge) relative to the output (animal welfare improvements) from a scientific perspective.

The fact that some of the main animal welfare issues persist also on organic broiler and laying hen farms accentuates the fundamental similarities between modern commercial organic and non-organic poultry production. Considering current knowledge of the domestic chicken and its evolutionary background, more pronounced changes in housing and management may be required in order to achieve greater welfare improvements, in agreement with the organic standards:

> [W]e need to take account of how the different species of animals originally were domesticated and what ecological function they fulfilled on the farm. In this way we can avoid wasting time seeking solutions elsewhere for problems that originate within the agricultural system itself. (Baars *et al.* 2004)

Unless we accept that some major welfare issues are inherent to the current way of housing and managing poultry in commercial production, it might be necessary to seriously explore alternatives to, rather than using research resources to make incremental improvements within, current poultry production systems.

7. Main conclusions

- Important welfare issues, not inherent to organic poultry production in particular, but associated with housing, management and genetics in modern commercial poultry production, can be found on organic farms. Severe feather pecking, keel bone damage and gait impairments, for example, reduce bird welfare due to the associated pain, stress and/or hampered mobility.
- In the broiler study, hock burns, dirty plumage and impaired gait were associated with higher body weight. 'Slow-growing' is a relative concept and to better comply with the animal welfare aspects of organic regulations, attention should be paid to the average daily weight gain in the broiler hybrids studied.
- The laying hen hybrids on organic farms are the same as in non-organic production, and welfare issues associated with *e.g.* high egg production and early onset of lay, such as keel bone damage, are prevalent also on organic laying hen farms.
- Free-range access may improve the quality of life for poultry by providing greater opportunities to forage and explore a more stimulus-rich environment. However, in general, the outdoor areas provided on organic farms in the present studies offered limited protection by vegetation cover and/or artificial shelters, and the majority of both broilers and laying hens were free-ranging in close proximity to the house.
- Due to the risk of predators, outdoor access can reduce poultry welfare. Predation occurred on all farms, but the perceived magnitude of the problem differed between individual farmers, as did the quality of the fences around free-range areas as protection against ground predators.

- Broilers appeared to be motivated as well as physically capable of perching, but the available space per bird on perches and other raised sitting areas was generally limited on all farms. For such raised sitting areas to increase the quality of life for broilers, sufficient amounts are required.
- Observations in broiler and laying hen flocks indicated a high fearfulness of humans. Humans enter the poultry house on a daily basis and if perceived as predators that inflict fear and other negative emotions, bird welfare might be reduced.
- In order to influence poultry welfare in practice, and not only in theory, the content of organic standards must transfer all the way to the farm. This may to a certain extent be managed by the individual farmer, but other undertakings might be obstructed by aspects contained within the structure of modern poultry production.

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Popular science summary

Animal welfare

Animal welfare is commonly considered to encompass the health status of an animal, its ability to express natural behaviour and lead a natural life, and its subjective feelings. Initially, welfare concerns focused mainly on meeting the animals' basic needs, but animal welfare discussions now entail also the concept of 'positive welfare' *i.e.* promoting pleasant experiences, rather than merely minimising unpleasant experiences.

Poultry production

Poultry production is one of the most intensive farming systems world-wide. Selective breeding has resulted in two distinct and highly specialised types of birds used for egg and meat production, *i.e.* laying hens and broilers, respectively.

There are around 460 million laying hens in the EU, of which the majority are kept in 'enriched cages' or in large flocks where the hens can move freely in a tiered system. Some of the main welfare issues in commercial egg production are severe feather pecking, *i.e.* pecking and pulling at the feathers of another hen, and keel bone damage, *i.e.* skeletal deformities and fractures of the breast bone.

Nearly 6.5 billion broilers were slaughtered for meat in the EU in 2020. Most broilers are housed on a littered floor in large flocks, often comprising thousands of birds. Genetic selection for rapid growth rate and high body weight has produced 'fast-growing' broilers, associated with severe welfare issues such as poor leg health and lameness.

Organic agriculture

The organic farming movement emerged during the first half of the 20th Century, partly in response to the intensification of agriculture. The basis of the organic movement is a holistic approach and an integrated agricultural system, which entails high animal welfare standards. To improve animal welfare, EU regulations on organic poultry production require lower stocking densities, use of 'slow-growing' broiler breeds, and provision of items that allow broilers to sit in an elevated position, natural light, at least eight hours of night rest, roughage and outdoor access. However, outdoor access is often viewed as one of the major challenges with organic poultry farming, as free-ranging involves exposure to predators and the risk of disease transmission through contact with wild birds.

Aim the of thesis

Studies performed on farms are important in order to increase our knowledge about animal welfare under commercial production conditions. In this thesis, data were collected on eight organic broiler farms and 11 organic laying hen farms in Sweden. Each farm was visited for one day, during which information on bird health and behaviour and on the indoor and outdoor environment, was collected through direct observations and in interviews with farmers. The aim was to investigate the present welfare situation on these farms in terms of housing, bird health and behaviour, outdoor access and free-ranging.

Results

The results, in agreement with previous research, showed that important welfare issues occur in organic poultry production. There was a high prevalence of plumage damage, which is indicative of severe feather pecking, among the laying hens in all flocks. Furthermore, half of all laying hens examined showed keel bone deformities. None of the broilers observed had severe walking difficulties, but around two-thirds showed minor to moderate gait impairments. These observations represent important welfare impairments due to the associated pain, stress and/or hampered mobility. Free-range access can improve poultry welfare by providing greater opportunities to forage and explore a more stimulus-rich environment. However, in general, the free-range areas offered limited protection by vegetation cover and/or artificial shelters, and outdoor observations indicated that the majority of birds remain close to the house when ranging. The free-range areas on some farms were equipped with robust fences, but others were not completely enclosed, offering limited protection against ground predators. The broilers appeared to be motivated as well as physically capable of perching, despite their high body weight. A variety of items were provided for perching, but the available space per bird on perches or other raised sitting areas was generally limited on all farms. Behavioural observations indicated that the broilers and laying hens were fearful of humans. Humans enter the poultry house on a daily basis and if birds perceive them as predators, this can cause fear and other negative emotions, reducing bird welfare.

Conclusion

In order to influence poultry welfare in practice and not only in theory, the content of organic standards must transfer all the way to the farm. Some aspects, such as provision of shelter or protection from predators in the free-range area, as well as the time spent with the birds on a daily basis can be managed at farm level. Other aspects, such as available breeds and certain features of commercial housing systems, are determined within the structure of modern poultry production and thus outside the control of the individual farmer. Considering current knowledge of the domestic chickens and its evolutionary background, more pronounced changes than what the current features of organic poultry production entail, may be required to achieve greater welfare improvements. However, as long as currently accepted baseline animal welfare standards in intensive poultry production serve as the reference point, the welfare improvements achievable on organic farms may be limited.

Populärvetenskaplig sammanfattning

Djurvälfärd

Djurvälfärd brukar definieras som en kombination av individens hälsa, dess möjlighet att utföra naturliga beteenden och leva ett naturligt liv, samt dess känslor och egna upplevelse. Tidigare handlade djurvälfärdsfrågor främst om att tillgodose djurens basala behov. Numera innefattar diskussionerna om djurvälfärd även vad som benämns 'positiv välfärd', det vill säga att främja positiva upplevelser, snarare än att enbart minimera negativa sådana.

Fjäderfäproduktion

Fjäderfäproduktion innefattar de mest intensiva djurproduktionssystemen i världen. Som ett resultat av genetisk selektion finns det idag värphöns samt slaktkycklingar, som specialiserats för ägg- respektive köttproduktion.

Det finns idag runt 460 miljoner värphöns inom EU, av vilka majoriteten för närvarande hålls i så kallade 'inredda burar', eller i stora flockar där hönsen kan röra sig fritt inomhus i ett våningssystem. Några av de viktigaste välfärdsproblemen i kommersiell äggproduktion inkluderar fjäderplockning (dvs. att hönorna rycker loss fjädrar från andra hönor) och bröstbensskador (deformationer och frakturer av bröstbenet).

Nästan 6,5 miljarder slaktkycklingar slaktades inom EU under 2020. De flesta slaktkycklingar hålls i stora flockar, ofta bestående av flera tusen individer, på en ströbädd i stora stallar. Allvarliga välfärdsproblem inom denna produktion inkluderar rörelsestörningar och hälta, som en följd av den intensiva aveln för snabb tillväxt och hög kroppsvikt som resulterat i så kallade 'snabbväxande' slaktkycklingar.

Ekologiskt lantbruk

Det ekologiska lantbruket tog form under första halvan av 1900-talet, delvis som en reaktion på intensifieringen inom lantbrukssektorn. Grunden i det ekologiska lantbruket är ett helhetsperspektiv, och ett lantbruk som bygger på det lokala kretsloppet. En grundpelare är högt ställda krav på djurvälfärd. EU:s regelverk för ekologisk fjäderfäproduktion kräver därför exempelvis en lägre beläggningsgrad, tillgång till upphöjda sittplatser som ger även slaktkycklingar möjlighet att sitta upphöjt, naturligt ljus och minst åtta timmars nattvila, grovfoder och utevistelse, samt användningen av 'långsamväxande' slaktkycklingraser. Utevistelse anses dock ofta vara en av de största utmaningarna med ekologisk fjäderfäproduktion, på grund av riskerna för sjukdom genom kontakt med exempelvis vilda fåglar, samt risken för rovdjursangrepp.

Avhandlingens syfte

För att öka kunskapen om lantbruksdjurens välfärd i kommersiell produktion, krävs studier som genomförs på sådana gårdar. Denna avhandling baseras på två studier från åtta svenska ekologiska slaktkycklinggårdar respektive 11 ekologiska värphönsgårdar. Varje gård besöktes under en dag, och gårdsbesöken innefattade observationer i stallet och i rasthagarna, samt intervjuer med lantbrukarna, för att samla in information om djurens hälsa och beteende, samt inomhus- och utomhusmiljö. Syftet var att undersöka djurens välfärd avseende inhysning, hälsa och beteende, samt utevistelse.

Resultat

Resultaten visar att viktiga välfärdsproblem, i enlighet med tidigare forskning, förekommer i ekologisk fjäderfäproduktion. Förekomsten av fjäderdräktsskador var hög i alla värphönsflockar, vilket tyder på att fjäderplockning var vanligt. Hälften av alla höns hade även bröstbensskador. Inga slaktkycklingar observerades med allvarlig hälta, men ungefär två tredjedelar uppvisade mindre eller måttliga rörelsestörningar. På grund av smärta, stress och/eller nedsatt rörlighet, representerar dessa fynd allvarliga välfärdsproblem. Utevistelse kan öka välfärden hos höns och kycklingar genom att erbjuda en mer stimulerande miljö och ökade möjligheter att utföra viktiga födosöksbeteenden. Rasthagarna erbjöd dock överlag begränsat med skydd i form av växtlighet och/eller artificiella strukturer, och utomhus vistades de flesta hönsen och kycklingarna i närheten av stallet. Vissa av rasthagarna kantades av robusta stängsel. På andra gårdar var dock rastgårdarna inte fullständigt inhägnade och gav således inte hönsen och kycklingarna ändamålsenligt skydd mot rovdjur. Slaktkycklingarna var både motiverade och fysiskt kapabla att använda de upphöjda sittytorna som erbjöds i olika former, trots sin höga kroppsvikt. Tillgången var dock begränsad på alla gårdar, vilket innebar att endast en del av kycklingarna hade möjlighet att använda dessa sittytor vid ett givet tillfälle. Beteendeobservationer visade på rädsla för människor hos värphönsen såväl som hos slaktkycklingarna. Eftersom människor dagligen vistas i stallen är det viktigt för djurens välfärd att människor inte uppfattas som skrämmande.

Slutsats

För att förbättra djurvälfärden i praktiken, och inte enbart i teorin, krävs att de ekologiska regelverken når hela vägen fram till gårdsnivå. Den individuella lantbrukaren kan till viss del påverka detta, till exempel genom att förse rasthagarna med skyddande växtlighet, artificiella skydd och lämpliga stängsel, eller genom tiden som dagligen tillbringas tillsammans med djuren. Andra aspekter, specifika för de kommersiella inhysningssystem eller de höns- och kycklingraser som i nuläget finns tillgängliga, exempelvis, beror snarare på faktorer inom strukturen för modern kommersiell fjäderfäproduktion. Med tanke på den kunskap som vi idag besitter om den domesticerade hönan och dess evolutionära bakgrund, krävs det förmodligen större förändringar än de som för närvarande innefattas av den ekologiska fjäderfäproduktionen, för att åstadkomma mer genomgripande välfärdsförbättringar. Så länge referenspunkten för god djurvälfärd utgörs av vad som idag accepteras inom mer intensiv fjäderfäproduktion, är dock omfattningen av sådana välfärdsökningar i ekologisk produktion sannolikt begränsad.

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Article

Bird Health, Housing and Management Routines on Swedish Organic Broiler Chicken Farms

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Simple Summary: Knowledge of bird welfare and management on Swedish organic broiler farms is limited, since the number of farms began to increase only recently when two slower-growing hybrids became commercially available in Sweden. The aim of the study was to obtain information about chicken health and other welfare aspects, along with details of housing and management routines, in order to increase the knowledge and describe the current situation of these farms. Clinical examinations revealed no severe remarks, however minor to moderate plumage dirtiness, food pad dermatitis and hock burns were found in 47%, 21% and 13% of the birds, respectively. Higher body weights were significantly correlated to an increased prevalence of hock burns and dirty plumages. Although no severe walking impairments were observed, minor to moderate gait abnormalities were seen in almost two-thirds of all birds assessed. Gait in chickens assessed outdoors was significantly better than in those observed indoors. Flock body weight uniformity was low in all flocks. The study provides new knowledge of two slower-growing hybrids on Swedish organic farms. Further research should be focused on investigating other important aspects related to bird welfare, such as the low flock body weight uniformity and the high mortality rates observed.

Abstract: Slower-growing broilers on organic farms have replaced fast-growing hybrids to increase bird welfare. Due to limited knowledge of broiler welfare and management on organic farms in Sweden, the study aim was to gather information regarding health, housing and management routines, in order to describe the current situation on these. Farm visits performed in 2018 included 8 out of 12 established organic farms, on which either Rowan Ranger or HubbardJA57/HubbardJA87 were reared. Chickens in the observed flocks were 55 ± 6 (44–62) days of age. Observations included farmer interviews, indoor environment assessments, clinical examinations and gait scoring. Clinical examinations revealed no severe remarks, however minor to moderate plumage dirtiness, food pad dermatitis and hock burns were found in 47%, 21% and 13% of the birds, respectively. Although no severe walking impairments were observed, minor to moderate gait abnormalities were seen in two-thirds of the birds. Gait in birds assessed outdoors was significantly better than in birds observed indoors. Body weight uniformity was low in all flocks. This study provides increased knowledge of certain chicken health and welfare aspects, housing and management on Swedish organic farms. Future research should further investigate important aspects related to bird welfare, such as the high mortality rates observed.

Keywords: slower-growing; welfare; foot pad dermatitis; hock burns; plumage; gait; body weight uniformity; mortality

1. Introduction

The concept of animal welfare encompasses the biological functioning and health of the animal, natural living and the possibility to express natural behaviour, as well as the subjective experience of the individual [1]. It has been proposed as a fourth dimension of sustainable animal farming [2], alongside the environmental, economic and social dimensions, and is one of the fundamental principles in organic agriculture [3]. Organic animal farming should thus comply with high animal welfare standards and promote animal health and well-being, with emphasis on species-specific behavioural needs [4]. EU regulations on organic broiler production require lower stocking densities and outdoor access for the birds [4], so as to better provide them with the opportunity to perform species-specific natural behaviours such as foraging and dust bathing. Chickens must also be provided with roughage during periods without outdoor access [5]. Natural light is obligatory and, when complemented by artificial light, a minimum period of eight consecutive hours without the latter is required for a nocturnal rest period [5]. To enable the best animal health possible under the prevailing production conditions, suitable hybrids should be selected for the purpose [4]. Fast-growing broilers have therefore been replaced by slower-growing hybrids [5], as the welfare of the latter and their suitability for organic production appear better [6–8].

The slower-growing hybrid Rowan Ranger® [9] became commercially available in Sweden during 2014, followed by Hubbard® [10] strains in 2016. In 2018, only 0.8% of total Swedish broiler production was organic [11]. The genetic variation within hybrids is a current problem on organic farms, making management and production unpredictable, as individuals within flocks tend to differ widely in body weight [12]. Moreover, organic poultry farming may involve animal welfare issues such as predation [13,14]. Numerous studies show that, despite their physical ability, only a small proportion of the flock ranges when given outdoor access and most chickens remain in close proximity to the house [15–18]. A number of studies have been situated in other European countries [6,17–19], but the majority of these seem not to have been performed under commercial settings, or under conditions compatible with those in Northern Europe.

Organic broiler production in Sweden at the time of the study was rather recent, and knowledge of bird welfare, production and management on farms is still limited. The aim of this empirical study was thus to collect information and accumulate knowledge of broiler health and other welfare aspects, along with details of housing and management routines, in order to describe the present situation on these farms. The aim further included the identification of areas of relevance for future research on organic broiler farms in Sweden.

2. Materials and Methods

This study comprised behavioural observations and clinical scoring of commercial broiler chickens without any invasive treatment, and thus ethical approval by an ethics committee for animal experiments was not required according to Swedish legislation [20].

2.1. Farm Visits

Based on an inventory of the current organic broiler farms in Sweden in 2018, the owners of these 12 farms were contacted by telephone. All eight farmers willing to participate in the study did so, with no particular selection of farms to be included in the study. These eight commercial organic broiler farms, all located in the southern third of Sweden, were visited during October (autumn) 2018.

Chickens in the observed flocks were 55 ± 6 (44–62) days of age at the time of the farm visits, which were performed as late in the production cycle and as close to slaughter as possible. The visits were completed on one day each, between 09.30–10.00 h and 15.00–15.30 h, by the first author and one assisting person. One farm was visited from 08.00 h for logistical reasons. All farmers were interviewed according to a structured protocol (Appendix A) covering management and husbandry routines, housing, bird health and behaviour, productivity, and free-range characteristics and utilisation. The farmers also received an e-mail questionnaire with open questions regarding their perceptions and opinions of organic broiler production. The farmers were contacted once more after the visits, to obtain abattoir records on the flocks observed during farm visits.

2.1.1. Housing and Indoor Environment

On each farm, indoor observations were made in one flock of broilers, in one rearing compartment, immediately after the interview with the farmer. If there was more than one flock of suitable age, the farmer selected the flock to be observed. On entering the rearing compartment, a piece of black paper was placed in an elevated position to assess the dust level, on a scale from a (none) to e (paper colour not visible), according to the Welfare Quality® assessment protocol for poultry [21]. Litter quality (Welfare Quality®) was then assessed on a scale from 0 (completely dry and flaky) to 4 (sticks to boots once compacted crust is broken) at five standardised locations in the rearing compartment, and the proportion of birds panting or huddling (Welfare Quality®) was recorded. These five locations were: "at the entry door", "below drinker (centre of rearing compartment)", "at pop-hole (centremost)", "halfway along outer short side" and "halfway along inner long side". Observations were always made in this order when walking through the rearing compartment. Dimensions of house and veranda (a roofed platform at ground level with three walls and one curtain, littered floor and natural ventilation, adjacent to the rearing compartment and connecting this to the free-range area) and number and location of windows, pop-holes, drinkers, feeders and indoor environmental enrichment were also recorded.

2.1.2. Gait Scoring and Clinical Examination

Five birds were gait-scored at each of the five locations (n = 25), using a six-point scale (Table 1). Completing a full rotation, the observer made five slow turns at each location. Following each turn, starting with the bird closest to the observer and counting to seven, one bird was randomly chosen and then gait-scored as the flock was gently encouraged to move. Gait scoring of an additional 25 individuals in the free-range area was then performed from the veranda, since walking in the free-range visible to the birds tended to scare the animals, hampering accurate observations. Birds were randomly chosen by counting to seven repeatedly, as during indoor gait scoring, but scanning from the left to the right side of the free-range area. If no birds were observed outdoors, only 25 individuals indoors were assessed. Birds on the veranda were not gait-scored.

In each flock, 50 birds were clinically examined. Individual handling of the chickens was done last during indoor observations. While walking slowly around the entire rearing compartment, making a complete circuit, groups of birds were confined until 50 animals had been examined. Approximately 3–15 birds at a time were confined against the wall using three connected compost grids. The birds were gently picked up one at a time, placed in a bucket with a lid and weighed, and thereafter clinically examined (Table 1).

Table 1. Scoring protocol for on-farm clinical examination and gait scoring of commercial organic broiler chickens (including references).

Measure	Scoring
Hock burns [1,2]	0 (intact skin, no redness)–4 (severe lesions)
Food pad dermatitis [1,2]	0 (intact skin)–4 (severe lesions)
Toe damage	0 (no damage); 1 (damage ≤ one toe); 2 (damage > one toe)
Plumage cleanliness [1]	0 (clean)–3 (very dirty)
Plumage condition [3] (body and flight feathers combined)	0 (good plumage condition, no or very few feathers damaged); 1 (completely or almost completely feathered with few feathers damaged, featherless area(s) <5 cm^2); 2 (highly damaged feathers, with featherless area(s) ≥5 cm^2); 3 (very high degree of damage to feathers, with no or only a few feather-covered areas)

Table 1. *Cont.*

Measure	Scoring
Skin lesions [4]	0 (no lesions, or <3 pecks or scratches); 1 (≥ one lesion <2 cm or ≥3 pecks or scratches); 2 (≥ one lesion ≥2 cm)
Comb wounds [4]	0 (no evidence of pecking wounds); 1 (wounds <3); 2 (wounds ≥3)
Comb colour	Normal; red; pale
Comb dehydration	Yes; no
Enlarged crop [4]	Yes; no
Signs of enteritis/diarrhoea [4]	Yes; no
Gait (lameness) [1]	0 (normal, dextrous and agile); 1 (slight abnormality, but difficult to define); 2 (definite and identifiable abnormality); 3 (obvious abnormality, affects ability to move); 4 (severe abnormality, only takes a few steps); 5 (incapable of walking)

[1] Welfare Quality® assessment protocol for poultry, applied to broiler chickens. [2] Both feet/legs examined: bird scored according to most severe lesion observed. [3] Adapted from Kjaer et al. (2006) [22]. [4] Welfare Quality® Assessment protocol for poultry, applied to laying hens.

The birds were marked with a black marker pen on one leg before release, to avoid examining the same bird twice. The assessor was trained in gait scoring and clinical assessment of chickens during a farm visit prior to data collection, which was further complemented by video materials for the purpose. The same person performed all clinical examinations and gait scoring of birds throughout the study.

2.2. Statistical Analyses

The Welfare Quality® assessment protocol was used for scoring certain welfare parameters in the study, however no indices were calculated according to the protocol. Data compilation and diagram creation were performed in Microsoft Excel (2016). All statistical analyses were performed in R [23]. Results are presented as mean value with standard deviation (min-max), unless otherwise stated. Results were considered significant when $p < 0.05$.

Fisher's exact test was used to analyse any dependence between the different locations in the rearing compartments and litter quality scores, as well as between floor heating and litter quality scores. The effect of litter quality on foot pad dermatitis (FPD) and hock burns (HB) was analysed through a logistic regression model. FPD scores were transformed into a binary variable (i.e., scores ≥ 1 were pooled), since scores ≥ 2 were few, before the analysis. Litter quality and body weight were included in the model. There was no interaction between these variables, hence interaction was not included in the model. For this analysis, the median of the five separate litter quality scores on each farm was used. Because litter quality scores were directly linked to the individual farms, farm was not included in the model.

The dependence between FPD and HB, between FPD and plumage cleanliness, and between HB and plumage cleanliness was analysed using Fisher's exact test. The association between body weight (BW) and age, respectively, and HB, FPD, and plumage cleanliness, respectively, was analysed using a logistic regression model. FPD and plumage cleanliness scores were transformed into binary variables (i.e., scores ≥ 1 were pooled), since scores ≥ 2 were few, before the analysis. Hybrid was included as a fixed factor, including the interaction between body weight and age, respectively, and hybrid. Since the participating farms comprised the majority of farms in the country and no randomised selection had been made, farm was also included as a fixed factor, as opposed to as a random factor.

Gait scores (GS) of birds observed indoors and outdoors were compared using Fisher's exact test. Due to the variations in age and average flock BW, which could largely impact GS, the two farms on which no birds were assessed outdoors were excluded from the analysis comparing indoor and outdoor gait scores. Fisher's exact test was also used to analyse the effect of BW on indoor GS (indoor scores only, since birds were not observed outdoors in all flocks). Due to the lack of data on individual BW, average flock BW was used for the analysis. There were two distinct groups with reference to average flock BW, one with heavier birds and one with lighter, which were used for comparison. The correlation between age and gait scores was analysed using a logistic regression model. Farm and hybrid were included as fixed factors, including the interaction between age and the latter.

Flock body weight uniformity was calculated according to Toudic (2007) [24], and compared between the two hybrids using the Welch two-sample *t*-test.

3. Results

All farms in the study were affiliated with the Swedish private organic incorporated association KRAV® [25], and certified according to KRAV standards [26]. On seven out of the eight farms studied, organic chicken production was established in 2012–2016 without prior chicken production on the farm. The remaining farm had previously had conventional broiler production before conversion to organic production in 2015. Only four of the eight farmers responded to the questionnaire regarding their opinions and perceptions of organic broiler production, thus this information was not included in any further analysis.

3.1. Animals and Farm Management

Rowan Ranger (RR) or Hubbard JA57/Hubbard JA87 (H), both slower-growing hybrids, were raised in mixed-sex flocks on five and three farms, respectively. The latter received day-old chicks (RR), whereas the former received eggs (H) for on-farm hatching. All farms had specific arrival compartments in which chicks were kept until around three weeks of age. Eggs were delivered to farms on Friday afternoons, following 18 days of incubation at a commercial hatchery. The farmers reported that hatching most commonly commenced during the following Saturday, or at most within five days after arrival of the eggs.

Artificial lighting was supplied continuously throughout the hatching process, as was it at arrival of the day-old chicks. A nocturnal period was thereafter induced within 3 ± 3 (1–7) days, through either an immediate (two farms) or gradual (six farms) decrease in artificial lighting. In the latter (specific information available from three farms only), this gradual decrease was by one or two hours per day. Initial temperature in the arrival compartments was 34.4 ± 1.5 (32–36) °C, which was gradually decreased to 22.9 ± 2.4 (20–26) °C during the three weeks before chicks were moved to the rearing compartment at 21 ± 1 (20–25) days of age. In the rearing compartment, indoor temperature was 18.2 ± 1.6 (16–20) °C on all farms except one, where smaller mobile houses were in use, in which indoor temperature was not regulated and was thus similar to the outdoor temperature. Chickens were allowed 8 (five farms), 8.5 (one farm), 9 (one farm) or 12 (one farm) consecutive hours of nocturnal rest without artificial lights. One farmer did not always consider artificial lights to be necessary in summertime, when natural light is ample, so some flocks were reared completely without artificial lighting. On all farms, at least during wintertime, chickens were provided with roughage (silage, hay, lucerne hay and/or straw) ad libitum, distributed loose on the floor or in nets, and/or in small square or large round bales.

Flocks on four of the farms were in general not vaccinated. On the remaining farms, flocks were either regularly vaccinated against Marek's disease, infectious bursal disease and/or coccidiosis (two farms) or vaccinated sometimes (depending on, e.g., availability of vaccine or disease outbreaks on neighbouring farms) against infectious bursal disease and/or coccidiosis (two farms).

Chickens were allowed outdoor access, most commonly veranda only at first, within approximately one week after moving to the rearing compartment, i.e., at 27 ± 2 (23–30) days of age. In general, free-range access was from 07.30–08.30 h until dark. In summertime, however, chickens on certain farms had continuous access to the veranda (three farms) and free-range area (one farm) also during the night. On all farms, outdoor access throughout the year was largely weather-dependent. The chickens were commonly allowed to free-range from spring (March–May) until autumn (September–November). The pop-holes were commonly closed during outdoor temperatures below 0 °C. Birds on all farms had outdoor access at the time of visit (October).

All organic chickens were slaughtered at the same KRAV-certified abattoir. The entire flock was slaughtered at once on five farms, at 63 ± 1 (62–65) days of age. On the remaining three farms, each flock was slaughtered on two separate occasions (thinning), at 59 ± 6 (53–63) and 66 ± 3 (64–69) days of age, respectively. The birds were manually caught for slaughter transport, one chicken at a time, and placed in crates that held six or seven birds each. Collection and transport were performed at night on all farms. Birds were either collected by trained teams (five farms) or by the farmers themselves (two farms), or a combination of both (one farm).

3.2. Housing

All farms but one (which had one arrival and one rearing compartment) had two arrival and two rearing compartments, respectively. Thus, four flocks could be kept concurrently in the latter. On five farms, the houses were new-built upon establishment of organic chicken production, and held two separate arrival compartments adjoining one rearing compartment each (Figure 1). The latter were approximately 647 ± 26 (600–700) m^2 each and intended for a maximum number of 4600–4800 birds. At placing of the flock, a maximum of 3% surplus is, however, accepted according to KRAV standards, motivated by the fact that it is difficult for the hatcheries to deliver an exact number (normally within −2 to +3%) of eggs or chicks. The order should, however, never exceed 4800 (or the maximum number of birds allowed in a compartment) individuals [27]. Old facilities (previously used for rearing pigs, turkeys or conventional broiler chickens) had been converted on three farms, and further complemented by new rearing compartments in two of these. Rearing compartments on one farm were currently under reconstruction, which is why eight previously used mobile houses were temporarily in place (Figure 2). These mobile houses were approximately 160 m^2 each and held around 1100 chickens after the birds had been moved from the arrival compartments.

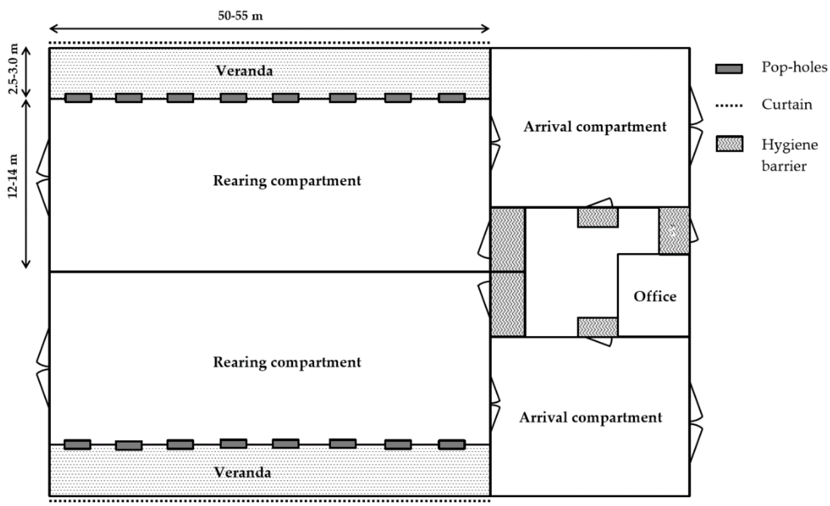


Figure 1. Schematic drawing of typical broiler house with standard rearing compartment dimensions as observed on five Swedish organic farms.

Figure 2. Mobile broiler houses on one Swedish organic farm.

Pop-holes were evenly distributed along the outer long side walls, and connected the rearing compartment to an adjoining veranda (Figure 1), which was present in all but the mobile houses. The number of pop-holes was 8 (six farms) or 10 (one farm) in the rearing compartments on all farms except the mobile houses, which had two pop-holes on each long side wall. Along the entire length of the veranda there was a single curtain (Figure 1), which was automatically or manually regulated for free-range access. Only the mobile houses had no windows for provision of natural light, but instead curtains (for manual regulation of ventilation) at ground level on each side of the house, which also functioned as light inlets.

The arrival and rearing compartments were each completely separate units, with no direct contact between the different flocks. Hygiene barriers were located outside the entrance of each compartment, as well as at the main entrance (Figure 1). Each compartment was emptied, cleaned and disinfected between flocks.

Indoor Environment

Bird density during farm visits (with reference to the number of birds and mean body weight at the time) in rearing compartments (veranda excluded) was 6.7 ± 0.5 (6.0–7.4) birds per m^2 or 17.1 ± 1.9 (14.3–19.3) kg per m^2. There were commercial nipple drinkers with drip cups (Big Dutchman® Top Nipple/Top Nipple Orange [28] on five farms, missing information for three farms) and commercial feeding pans (Big Dutchman® FLUXX 330/360 [28] on five farms, missing information for three farms) on all farms. The total number of drinkers in each of the observed rearing compartments (mobile houses excluded) was 555 ± 145 (411–759) and the total number of feeding pans was 131 ± 25 (102–179). There were 9.1 ± 2.1 (6.3–11.7) birds per drinker and 37.7 ± 6.6 (26.8–47.1) birds per feeding pan, with reference to the maximum number of birds allowed in the rearing compartments.

Wood shavings were used as litter material on three farms. Wood shavings and peat (two farms), wood shavings and straw (one farm), and straw only (one farm) were also used. On three farms there was underfloor heating in the rearing compartments, however this was utilised only on two of these farms. Litter quality scores (Figure 3) were not correlated to location in the rearing compartment (p = 0.72) or to use of underfloor heating (p = 0.16). Because the litter quality assessment criteria (Welfare Quality®) were not applicable to the straw used as litter material on one farm, this was excluded from the analysis. The straw used as litter material on this farm was, however, without remarks.

No birds were observed panting or huddling during any of the farm visits. The dust sheet test results showed “minimal evidence of dust” on seven farms and “no evidence of dust” on the remaining farm (with mobile houses and straw as only litter material). During farm observations, there was olfactory evidence of ammonia on three farms, while there was no sensory indication of ammonia on the remaining five farms.

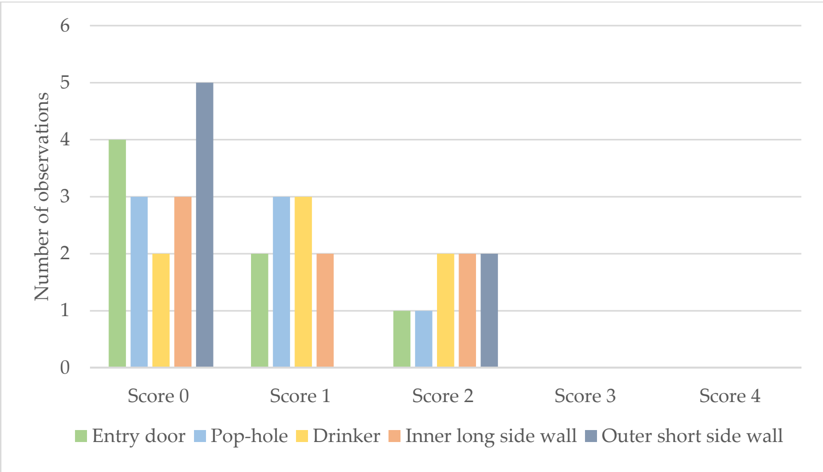


Figure 3. Litter quality assessment scores (Welfare Quality®) for Swedish organic broiler farms ($n = 7$): number of observations ($n = 35$) with score 0–4 at five standardised locations in rearing compartments.

3.3. Health

3.3.1. Foot and Leg Health

The total proportions of birds ($n = 400$) with different foot pad dermatitis (FPD) and hock burn (HB) scores are shown in Figure 4. No birds received FPD scores ≥ 3 or HB scores ≥ 2. The prevalence (min-max) of FPD (0–58%) and HB (0–26%) varied widely between the different flocks (Table 2).

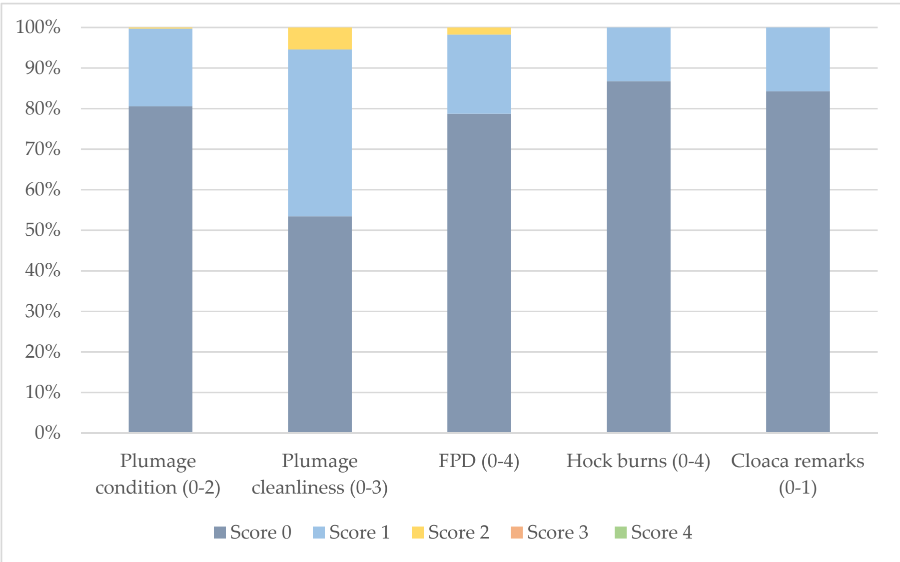


Figure 4. Proportion (%) of chickens ($n = 400$) with different plumage condition, plumage cleanliness, foot pad dermatitis (FPD) and hock burn scores and cloaca remarks (0 = no remarks, 1 = signs of enteritis/diarrhoea) (Welfare Quality®) in flocks ($n = 8$) observed on Swedish organic broiler farms.

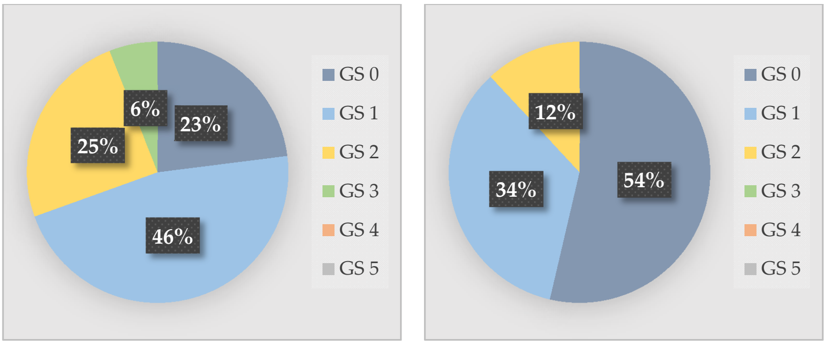
Table 2. Proportion (%) of chickens (n = 50) in each flock (n = 8) with different plumage condition, plumage cleanliness, foot pad dermatitis (FPD) and hock burn (HB) scores and cloaca remarks (signs of enteritis/diarrhoea) (Welfare Quality®) on Swedish organic broiler farms. (H: Hubbard; RR: Rowan Ranger).

Farm	Hybrid	Age (Days)	Plumage Condition [1]			Plumage Cleanliness [1]			FPD [2]			HB [3]		Cloaca Remarks	
			0	1	2	0	1	2	0	1	2	0	1	No	Yes
1 [4]	RR	55	-	-	-	62	34	4	84	16	0	88	12	98	2
2	RR	62	100	0	0	4	76	20	52	48	0	74	26	100	0
3	H	55	84	14	2	78	22	0	82	18	0	96	4	92	8
4	RR	57	32	68	0	52	44	4	98	2	0	100	0	56	44
5	H	44	100	0	0	86	14	0	86	14	0	94	6	80	20
6	RR	48	100	0	0	58	40	2	100	0	0	86	14	88	12
7	H	57	48	52	0	34	58	8	42	44	14	80	20	100	0
8 [5]	RR	58	100	0	0	-	-	-	86	14	0	76	24	60	40

[1] Plumage condition and cleanliness: no birds scored 3. [2] FPD: no birds scored ≥3. [3] HB: no birds scored ≥2. [4] Scores excluded due to moulting. [5] Scores excluded due to chickens being wet and muddy because of current weather conditions.

The prevalence of HB increased significantly with increasing body weight (BW) ($p < 0.001$), but the prevalence of FPD did not ($p = 0.64$). Age was not correlated with the prevalence of either HB ($p = 0.17$) or FPD ($p = 0.82$). There was no correlation between HB and FPD ($p = 0.11$). Worse litter scores were significantly correlated with a higher prevalence of FPD ($p < 0.001$) and HB ($p < 0.01$). Residuals of the fitted models were found to be adequate. No toe damages were observed in any of the birds.

Chickens were gait-scored indoors (n = 200) and, when possible, outdoors (n = 151). On two farms, no birds were observed free-ranging. No birds scored ≥4, and all birds with GS 3 were observed on four of the farms during indoor assessments. GS were significantly lower (better) in birds observed outdoors than in birds observed indoors ($p < 0.001$). The proportion of birds observed without remarks was more than twice as large among birds outdoors than indoors (Figure 5a,b).



(**a**) (**b**)

Figure 5. Proportion of chickens (n = 300) with gait score (GS) 0–5 (Welfare Quality®) on six Swedish organic broiler farms: (**a**) Chickens scored indoors (n = 149); (**b**) Chickens scored outdoors (n = 151). Two farms were excluded for the comparison, as no birds were observed outdoors in these flocks.

Indoor GS were significantly higher ($p < 0.05$) in flocks with mean BW ≥ 2594 g (six farms) compared with flocks with mean BW < 2150 g (two farms). No correlations between age and gait scores were found ($p = 0.11$).

3.3.2. Integument

The total proportions of birds (n = 400) with different plumage condition and plumage cleanliness scores are shown in Figure 4. No birds received score 3 during this assessment. The prevalence (min-max) of feather damage (0–68%) and dirty plumage (14–96%) varied widely between the different flocks (Table 2). Plumage condition scores from one farm were excluded due to moulting in the flock.

Plumage cleanliness scores from another farm were excluded as chickens were wet and muddy due to current weather conditions. There was a significant correlation between dirty plumage and FPD ($p < 0.01$), and between dirty plumage and HB ($p < 0.001$). The prevalence of dirty plumages increased significantly with increasing BW ($p < 0.001$) and with increasing age ($p < 0.05$). Residuals of the fitted models were found to be adequate.

Comb colour was normal in all chickens examined and no comb dehydration was observed. Comb wounds (score 1) were found in 0.5% of all birds. No comb wounds were observed in the remaining birds. Skin lesions were found in 2% (score 1) and 0.3% (score 2) of all birds.

3.3.3. Gut Health

The total proportions of birds ($n = 400$) with signs of enteritis (diarrhoea) are shown in Figure 4. The prevalence (min-max) of enteritis (diarrhoea) (0–44%) varied widely between the different flocks (Table 2). Enlarged crops were found in 1% of all birds.

3.3.4. Body Weight

In each flock, a clinical examination of 50 birds was performed ($n = 400$). Average body weights varied between 1947 and 2800 g (Figure 6) due to age differences between flocks. Flock body weight uniformity, expressed as a coefficient of variation (CV), was 15.0 ± 2.8% (11.8–20.7). The CV was significantly ($t(5.05) = 3.51$, $p < 0.05$) higher (i.e., flock weight uniformity lower) in RR flocks ($M = 16.5$, $SD = 2.4$) than in H flocks ($M = 12.5$, $SD = 0.7$).

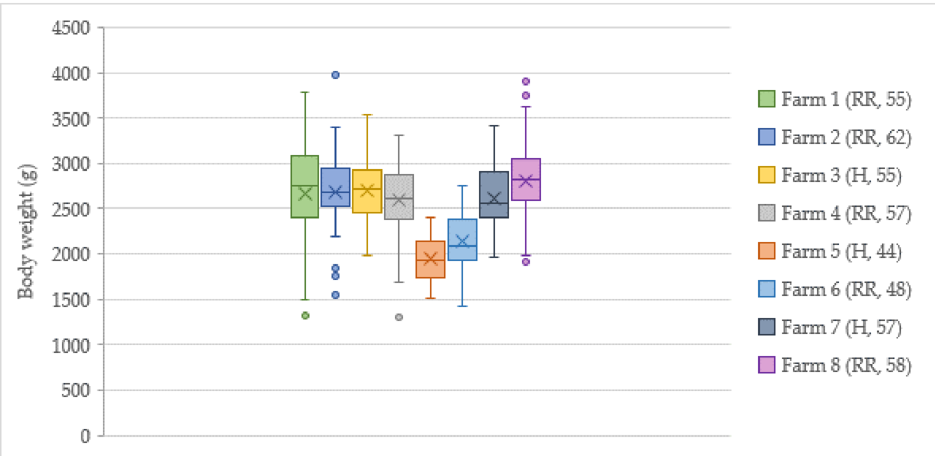


Figure 6. Distribution of chicken body weights in birds assessed ($n = 50$) in flocks on Swedish organic farms ($n = 8$). Hybrid (H: Hubbard; RR: Rowan Ranger) and age (days) within brackets.

3.4. Production

The average flock mortality over time estimated by the farmers was 3.4 ± 0.9% (2–5) (Table 3). Mortality reasons reported were presumed heart failure (four farms), predators (three farms, of which one regarded it as a minor problem), general weakness or other unknown reasons in young (age <5 days) chicks (three farms), leg problems in older chickens (one farm), and stargazers, i.e., birds whose head and neck is retracted in an abnormal twisted position due to various aetiologies (one farm). Culling of chickens was mainly due to leg problems, general weakness and reduced growth. Farmers reported that the number of chickens culled varied throughout the production cycle, ranging from none during some weeks to several chickens during other weeks.

Table 3. Mortality (%) and eggs discarded (%) on Swedish organic broiler farms (*n* = 8). Observed flock mortality (at visit) calculated with reference to original number of eggs/chicks and number of birds in flock at the time of visit (information provided by farmer estimates and/or computer production records). Observed flock mortality (post-slaughter) calculated with reference to original number of eggs/chicks and number of birds delivered to the abattoir.

		Farmer Estimates (%)			Calculated (%)	
	Age (Days)	Eggs not Hatched/Discarded	Average Mortality Over Time (All Flocks) [1]	Observed Flock Mortality [1] (at Visit)	Observed Flock Mortality (at Visit)	Observed Flock Mortality (Post-Slaughter)
On-farm hatching						
Farm 1	55	8–10	4	6	6.7 [3]	n/a [5]
Farm 2	62	4	4–4.5	6	6.7 [3]	8.9 [3]
Farm 4	57	8–10	4–5	5–6	7.7 [3]	9.5 [3]
Farm 6	48	5–6	2–3	2.2 [2]	10.2 [3]	n/a [5]
Farm 8	58	5–10	3.5–4	3.5–4	n/a [4]	n/a [5]
Day-old chicks						
Farm 3	55	n/a	2–3	5–6	6.5	n/a [5]
Farm 5	44	n/a	2	3–4	4.9	7.4
Farm 7	57	n/a	3–4	3.5 [2]	3.5	7.1

[1] Unknown whether eggs not hatched/discarded (where relevant) are included in this estimate. [2] Information obtained from computer production records. [3] Mortality rates including eggs not hatched/discarded due to lack of information on number of chicks hatched. [4] Estimate of original and current number of birds too vague for reliable calculations. [5] No information on number of birds delivered to abattoir available.

Average live BW at slaughter was estimated to be around 2500–3000 g by all farmers except one (who would not make an estimate due to the aforementioned large variations in BW within flocks), with an average daily weight gain of 45–50 (52) g. Average feed conversion rate (FCR) was estimated by the farmers to be approximately 2.0–2.4 kg feed per kg live weight (seven farms) and 2.6–2.7 kg (one farm).

Abattoir records on the flocks observed during farm visits could only be obtained for four of the farms, which is why this information was not included in any further analysis.

4. Discussion

4.1. Housing and Indoor Environment

Slower-growing hybrids were reared on all farms in compliance with EU regulations [5]. Rearing compartments held no more than 4800 chickens, also according to EU regulations, and bird density at the time of farm visits did not exceed the maximum allowed limits (10 chickens/m^2 or 21 kg/m^2) [5]. The latter was, however, calculated based on farmer estimates, and thus holds some uncertainties. The chickens on all farms were provided with natural light, and artificial lights were turned off for at least eight consecutive hours per day [5]. Birds had outdoor access from spring to autumn, and were provided with roughage at least during wintertime when free-ranging opportunities were restricted, as reported by all farmers.

The dust level was low on all farms, and the temperature most likely within the birds' thermal comfort zone, as reflected by the absence of any birds panting or huddling. Five farmers, however, described difficulties maintaining the indoor temperature, as well as high heating expenses, with decreasing outdoor temperatures. Ventilation may be reduced to conserve heat, but commonly results in a subsequent increase in humidity and, e.g., ammonia concentrations [29–31]. The former has been associated with deteriorating litter quality [32], in turn associated with FPD and HB [33,34], of which a higher prevalence has been demonstrated during colder seasons [29–31]. The study was performed during the autumn season, thus results regarding litter quality, FPD and HB may have been different in winter or summertime. Only on one farm was litter quality without any remarks. On the remaining farms, at some locations in the rearing compartment, the litter was not dry and loose but compacted and with a solid upper layer, however it was not wet or sticky. Litter of such quality would thus also function poorly as dustbathing material. Maintaining an optimal indoor environment during colder seasons is a well-known issue also in conventional broiler production, further complicated here in housing systems in which the outdoor environment influences the indoor environment through direct communication. Not only can this affect animal welfare in terms of negative effects on physical health, but furthermore, flocks reared in wintertime may never be provided with outdoor access.

4.2. Farm Management

The interviews with farmers indicated that there are differences between farmers' attitudes and motivational factors, but also revealed discrepancies regarding management routines (e.g., vaccination routines, lighting and temperature programmes, veranda and free-range access). This is in contrast with conventional broiler production, which is often very homogenous and where highly standardised management manuals (e.g., [35,36]) are available for the common fast-growing broiler strains. The rearing of slower-growing organic broilers is, however, without any such precise manuals, and appears to be more heterogeneous, even amongst the few farms included in this study. Ideal farm management might not necessarily be achieved through one single uniform approach, but could perhaps comprise different approaches depending on adaptations to the individual flock, farm and farmer. Thus, this heterogeneity amongst farmers and management might perhaps constitute a strength, and should be further investigated from both an animal welfare as well as a production perspective.

4.3. Health

4.3.1. Foot Pad Dermatitis and Hock Burns

Foot pad dermatitis and hock burns are painful conditions [37] and are acknowledged welfare issues among commercial broiler chickens [37,38]. Reports on FPD and HB prevalence in commercial slower-growing organic broilers are scarce, however, and a comparison of findings is further hampered by the different scoring systems used [39]. In this study, approximately one-fifth of all birds were observed with minor to moderate signs of FPD, which is notably lower than in other studies on slower-growing chickens with outdoor access reared under research [15] or commercial [39–41] conditions. No birds in the present study had severe lesions, again in contrast to the previous studies. Mild signs of HB were observed in 13% of all chickens, whereas the remaining animals assessed had no signs of HB. Similar results were found in earlier studies on slower-growing hybrids, however these were reared under experimental conditions with [15,42] or without [43,44] winter-garden or outdoor access. The absence of moderate and severe HB lesions is in contrast to some earlier findings [42,43], but in agreement with others [44].

Foot pad dermatitis and hock burns have been associated with a number of different factors, which might explain the discrepancies between the present and previous results. Numerous studies demonstrate a significantly increased risk of FPD [31,33,34,45,46] and HB [33,34] when birds are exposed to deteriorated (moist) litter. A significant correlation between poorer litter quality and FPD and HB prevalence was also found in the present study. Outdoor access [41,47] and more frequent range visits [48] have been found to correlate to an increased prevalence of FPD, whereas the opposite has been concluded in other studies [19,40]. More locomotor activity and less contact with litter has been suggested as an explanation for the latter [15,19]. However, outdoor weather conditions are not always optimal, and birds may also be exposed to moist ground as a consequence of high humidity and precipitation [47]. HB prevalence increased significantly with increasing BW, as observed previously [15,31,42,48–50], presumably as a result of heavier birds spending more time sitting down with their hocks in contact with the bedding [49]. However, there was no significant correlation between FPD prevalence and BW, which is in agreement with some earlier studies [49,51], but in contrast with others [47,50]. FPD and HB have been associated with different genotypes [31,43,47,49,51,52], with a significantly lower prevalence in slower- compared with fast-growing chickens [43,44,47,49,50,53]. The latter, in combination with more physical activity, lower stocking densities and overall good indoor environments, may contribute to the relatively good foot health in these birds, despite the challenges associated with the Nordic climate.

4.3.2. Gait

Free-ranging and outdoor access have previously been correlated with better gait in fast- [48,54,55] and slower-growing [15,42,54] broilers. In the present study, the GSs in birds observed outdoors were, as expected, significantly lower (better) than in birds observed indoors. Whether birds with lower (better) GSs are more prone to use free-range areas, or whether gait improves as a consequence of outdoor physical activity, is not completely clear. The latter has, however, been demonstrated in previous studies [48,55]. Outdoor access as such, provided that the chickens free-range when given the opportunity, can thus contribute to improved leg health, and consequently better welfare in broilers.

Lameness in broilers has been associated with rapid growth rates [43,56] and high BW [15,42,43,50,56]. Numerous studies show significantly lower (better) GSs in slower-growing chickens compared with fast-growing [44,54,56–58]. In previous studies of slower-growing chickens reared under commercial organic [58] or research conditions without outdoor access [42–44], no or only a few individuals with the highest (worst) GS were observed. Similarly, in the present study no birds with severe walking impairments were observed. Whether this finding reflects an absence of such walking impairments in the birds studied, or that severely lame animals are appropriately culled by farmers, is, however, unknown.

Gait scoring was performed without confining the birds, to avoid assessing only birds that were less agile or unable to move away, and thus the analysis was limited by the lack of known of individual body weights. However, the GSs for chickens in flocks with a lower average body weight were significantly lower (better) than GSs for chickens in flocks with a higher average body weight. These results must, however, be regarded taking into consideration the low BW uniformity in the flocks observed. Studies show that at least moderate and severe lameness are associated with pain [59,60]. Impaired mobility is, however, also a welfare issue considering that it might hinder the performance of natural behaviour or hamper access to resources. It is an important welfare parameter, with need for improvements to ensure the welfare of the slower-growing broilers within the studied organic production system.

4.3.3. Plumage

Maintaining an intact and healthy integument is essential for bird welfare [61]. The plumage in approximately half of all chickens in the present study was considered slightly or moderately dirty, whereas in the other half it was without remarks. In previous studies on slower-growing hybrids, none of them performed under commercial rearing conditions however, and only one on birds with free-range access [15], the proportions of birds with clean plumage reported have been lower [15,43] as well as higher [42]. No birds were assessed as very dirty in the present study, in accordance with the aforementioned studies [42,43].

The plumage can become wet or soiled with, e.g., litter of poor quality, faecal matter and dirt. With outdoor access, chickens are exposed to variable weather conditions and thus an intact plumage, which is essential for thermoregulation, is particularly important. It has been suggested that outdoor access might improve plumage condition [55,62], but also that individuals with a clean and intact plumage may be more prone to use free-range areas [55]. Plumage cleanliness decreased significantly with increasing BW and age, in agreement with earlier observations [15,43,44]. There was also a significant correlation between dirty plumage and FPD as well as HB. Heavier individuals are likely more prone to become fouled from contact with the bedding and from conspecifics, since it has been shown that these birds spend a large proportion of time sitting down [7]. The relatively cleaner plumage observed in slower-growing chickens compared with fast-growing ones has been explained in the same way [44,57], as the former tend to walk and stand more [6]. Furthermore, access to dust bath materials and the lower stocking density in organic broiler production enables the birds to perform, e.g., grooming and dust bathing behaviour to a greater extent [63], which is important for the maintenance of plumage cleanliness.

The majority of the chickens had no or minor feather damages, as also found in previous studies on slower-growing hybrids [6,53], whereas birds in three particular flocks were observed to have minor to moderate damages. Feather pecking amongst chickens and injuries from objects in the environment can cause feather damage and abrasions or other skin lesions. No particular risk factors were identified in the latter flocks, however. Feather pecking is a major welfare problem among laying hens, in which it has been thoroughly studied, while corresponding research on broilers is limited and does not provide sufficient knowledge of the occurrence of feather pecking and cannibalism. Some of the farmers in this study mentioned injurious pecking as a potential consequence of various flock disturbances, but appeared to be aware of when and how to prevent any outbreaks. Studies comparing slow- and fast-growing broilers report significantly better feather conditions in the former [6,57]. It has also been demonstrated that free-ranging may improve plumage condition and reduce feather pecking in laying hens [64–66]. Good management, free-range access and slower-growing hybrids seem thus to be a promising combination for intact plumage, which was predominantly observed in the present study. However, the large proportion of individuals with dirty plumage indicates a need for improvement in factors related to chicken growth and management, in order to ensure good animal welfare in this regard.

4.4. Production

4.4.1. Average Daily Weight Gain

Although the growth rate in slower-growing broilers is reduced, this is only in relation to other, more fast-growing hybrids. This is clearly illustrated, e.g., by the current definition of slower-growing used in Germany (cit. [42]), according to which growth rate may not exceed 80% of the daily growth of genotypes bred for top efficiency. Under Swedish regulations, slower-growing hybrids may have an average daily weight gain of 45 g at most [67]. However, the farmers in the present study reported an average daily weight gain of 45–50 g, and sometimes as high as 52 g. The results of this study show that welfare issues attributable to chicken growth rate are still present in slower-growing hybrids, e.g., hock burns and impaired gait, and thus limiting the average daily weight gain is important from both an animal welfare and legal perspective.

4.4.2. Flock Body Weight Uniformity

Flock uniformity is a measure of the spread of live weight in relation to the flock average, often defined as the proportion of birds within 10% of the mean flock body weight. It is commonly expressed as coefficient of variation (CV) [68], which should not exceed 10% according to general recommendations [24,69]. The CV in all flocks observed in this study was notably higher than 10%.

Various management and environmental factors have been shown to influence broiler flock weight uniformity [24], such as management and age of broiler breeders, incubation and brooding conditions, nutrition [70–73] and feeding management practices [74,75], ventilation, breed [70,71] and health problems. The limited number of studies on flock uniformity in broilers are on fast-growing hybrids [68–71]. In general, uniformity decreases with increasing age in mixed-sex flocks, due to the faster growth rate in males compared with females [70,76]. Thus, flock variations might become more pronounced in slower-growing broilers, since they are reared for a longer time. It is possible that a flock with high CV in reality consists of two uniform sub-populations, females and males [24]. However, histograms of flock body weights refuted this as an explanation for the large variations in all flocks observed. It has also been suggested that additional floor space at lower stocking densities may allow some individuals to grow more, and hence negatively affect uniformity [69].

Flock weight uniformity was significantly higher in Hubbard compared with Rowan Ranger flocks. Genetic factors, management and age of broiler breeders, egg incubation conditions (RR chicks were hatched on-farm, while H chicks arrived as day-olds) and flock age are possible factors that may have contributed to this difference. High flock weight uniformity is desirable from a production perspective, as poor uniformity has been associated with increased FCR, reduced growth rate and higher mortality, and as large variations in BW may indicate or create health and other welfare issues [68]. Furthermore, anecdotal information suggests that the parent stock hens may not have been sex-separated completely before sexual maturity, and hence dwarf cockerels may have fertilised some of the eggs thereafter collected as broilers. Whether these comparatively very small, but seemingly healthy, birds experience reduced welfare in a flock amongst larger conspecifics is unknown, but they will, however, have negative implications for the workload and economics of production.

4.4.3. Mortality

In general, information about mortality rates and production parameters such as FCR was difficult to obtain from the farmers. Few of the farmers in this study could provide detailed farm and flock information, and most gave only (rather vague) estimates. There was a noticeable discrepancy between calculated flock mortality based on production data and the estimates provided by the farmers, with the farmers generally appearing to underestimate chicken mortality. However, farmer estimates (where relevant) presumably did not include the proportion of eggs discarded or not hatched, while the corresponding calculations did, and thus these mortality rates would appear higher. Moreover, there were some uncertainties in the calculations, since, e.g., the number of birds in the observed flock at the time of visit was often an estimate. One of the main mortality reasons mentioned was predation, which further hampers accurate estimations of the flock size at a particular point in time. The observed flock mortalities calculated post-slaughter were notably higher than the farmer estimates of average, as well as observed, flock mortality. The former was around 7% in two flocks on farms to which day-old chicks were delivered (around 9% in two flocks on farms to which eggs were delivered, mortality rate thus including the proportion of eggs not hatched). This is notably higher than the mean mortality rate reported in other studies (around 1–3%) performed on commercial farms, in both organic slower-growing hybrids [58,77] and conventional fast-growing chickens [58,68,78]. This is also lower than some of the farmer estimates of average mortality rates over time. Further studies should thus be undertaken on Swedish organic broiler farms to scrutinise the mortality rates and reasons, as this may reflect severe welfare issues. Moreover, due to the inclusion of eggs discarded or not hatched in the calculations, flock mortality rates at visit and post-slaughter, respectively, were in general higher on farms with on-farm hatching compared to farms which received day-old chicks. While these figures thus do not allow for a direct comparison of actual mortality between the two systems, they could indicate that receiving the same number of eggs and day-old chicks, respectively, might constitute an economic disadvantage if a proportion (up to 10%) of the former never hatch. Further studies on this, as well as the animal welfare implications of on-farm hatching, are thus required.

4.5. Limitations of the Study

To the best of our knowledge, there were only four other organic broiler farms (not included in the study) in Sweden at the time of the study, of which one declined when asked to participate and three were unsuccessfully contacted. Thus, the eight farms visited represent the majority (i.e., 66%) of all commercial organic broiler farms in Sweden, and the results can therefore be considered to provide a solid basis for describing the current situation. The low number of farms is still a considerable limitation, however. The limited number of farms prevented statistical analysis of, e.g., differences between the two hybrids, as it was not possible to tease apart hybrid from other individual farm-related factors, such as, e.g., on-farm hatching (all RR flocks) and the placing of day-old chicks (all H flocks). Moreover, due to the lack of repeated observations, specific management routines or environmental determinants were difficult to statistically analyse in relation to health scores. Repeated farm visits, during a production cycle and in more than one flock, would have enabled observations in a broader context, i.e., different weather conditions or alterations in husbandry routines. Farms were visited in October, and because free-range access was a requirement, flocks were observed as close to slaughter as possible but while birds still had outdoor access. Thus, this resulted in some age variations between flocks, which creates further difficulties in the comparison between these, and ideally birds in all flocks would have been observed at similar ages. On farms where more than one flock was of suitable age, the farmers decided on which flock to be observed. A simple method for randomisation in these cases could have been applied to prevent this potential bias.

5. Conclusions

To our knowledge, empirical studies of slower-growing broilers on organic commercial farms are rare. This study provides increased knowledge and a first, although limited, overview of certain health and welfare aspects, housing and management on organic broiler farms in Sweden. Severe health issues were rarely observed during clinical examinations, although birds with minor to moderate lesions and remarks, concerning, e.g., foot and leg health and plumage condition, were found. Higher body weights were significantly correlated to an increasing prevalence of hock burns and dirty plumages. Gait in birds assessed outdoors was significantly better than in birds observed indoors, which may indicate that free-ranging has a positive effect on broiler leg health. In order to better comply with the animal welfare incentives of organic regulations, attention should be paid to the average daily weight gain in the two hybrids studied. Future research should aim at investigating important aspects related to bird welfare, such as the low flock body weight uniformity and the high mortality rates observed in this study.

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Appendix A

Table A1. Questionnaire used in interviews with farmers on Swedish organic broiler chicken farms.

Questions		
General information	Hybrid	Rowan Ranger ◻ Hubbard ◻ Other:
	Organic production	Since year: Conventional before: ◻ Yes ◻ No If yes, since year:
	Buildings	New ◻ Rebuilt ◻ Maximum capacity (number of birds): Same number of birds winter-/summertime: ◻ Yes ◻ No
	Observed flock	Current age: Original number of birds: Current number of birds: Current average body weight:

Table A1. *Cont.*

Questions		
Hatching and young chicks	Hatching	On-farm □ or day-old chicks □ If on-farm hatching, brooding days: Name of hatchery: Distance transported:
	Arrival rooms	□ Yes □ No If yes, age when moved to rearing room: If yes, method for moving to rearing room:
	Indoor environment	Temperature scheme (C°): Natural light: □ Yes □ No Artificial light scheme (hours):
	Medical treatments	Vaccinations: □ Yes □ No If yes, what: Other medical treatments: □ Yes □ No If yes, what:
	Critical points	□ Yes □ No If yes, age(s) or phase(s): Measures of prevention:
Housing (rearing compartment)	Indoor environment	Temperature (C°): Natural (N) light: □ Yes □ No Artificial (A) light type: Night time (A) (hours): Dusk and dawn simulated (A): □ Yes □ No If yes, time/duration: Litter type: Underfloor heating: □ Yes □ No
	Air quality	Ventilation type: Ammonia monitoring: Ammonia regulation:
	Environmental enrichment	Object(s): Amount/number: Distribution: Time of year provided: Age of installation:
	Roughage	Type(s): Supplier: Amount: Distribution: Time of year provided:
Production	Mortality	This flock (%): Average (%): Main reasons:
	Culling	Average number of birds: Main reasons:
	Hatching	% of eggs discarded/not hatched:
	Slaughter	Thinning: □ Yes □ No Age(s): Abattoir: Distance transported: Harvesting: Trained team □ Selves □ Comments on harvesting:

Table A1. *Cont.*

Questions		
	Growth	Expected average slaughter weight: Average daily weight gain: Feed conversion rate:
	Feed specifics	Supplier: Starter (type and age period): Rearing (type and age period): Finisher: (type and age period):
Outdoor area	Free-range access (pop-holes/curtain open)	From age: Hours per day: Months per year: Weather conditions:
	Birds' free-ranging behaviour	Age when first ranging: Weather conditions preferred by chickens: Weather conditions disliked by chickens: Average distance from house (m): Maximum distance from house (m):
	Predators	Problem: ◻ Yes ◻ No If yes, what species: Measures of prevention:
	Free-range characteristics	Area:
		Vegetation: Natural ◻ Planted ◻

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II

animals

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Article

Behaviour in Slower-Growing Broilers and Free-Range Access on Organic Farms in Sweden

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Simple Summary: Outdoor access, environmental enrichment and more slower-growing hybrids are means to improve broiler welfare in organic production. Two slower-growing hybrids are currently reared on organic farms in Sweden, but knowledge of bird welfare is limited. Therefore this study surveyed chicken behaviour, including free-range use and features of this, on Swedish organic farms. The results showed that, even towards the end of their production cycle, the chickens were agile enough to ascend various objects for perching. The birds were highly motivated to do so and were provided with a variety of items for perching across farms, but the quantity appeared to be insufficient. On average, almost half of all birds observed on the floor, were in a sitting posture. Free-range areas generally lacked sufficient vegetation cover or artificial shelters, and chickens were mainly observed ranging close to the house. This is novel information on the behaviour and free-range use of two slower-growing hybrids on Swedish organic farms. Key improvements to the indoor environment (e.g., environmental enrichment) and outdoor environment (e.g., vegetation or artificial shelter) could increase broiler welfare. Further research should explore feasible ways for farmers to implement such measures.

Abstract: Two slower-growing hybrids (Rowan Ranger and Hubbard) are currently reared in organic broiler production in Sweden, but knowledge of bird welfare on commercial farms is limited. This study examined chicken behaviour, including free-range use and features of this, in order to enhance knowledge, describe the current situation and identify practical solutions on Swedish organic broiler farms. Eight of 12 available farms were visited once each, when average flock age was 55 ± 6 days. Farmer interviews were followed by avoidance distance tests, group behavioural observations, and assessment of use of environmental enrichment and free-range by the chickens. On average, almost half of all birds observed indoors were in a sitting posture. However, even when approaching slaughter age, the chickens were agile enough to perch and used some of the variety of items provided for perching, but the quantity of environmental enrichment equipment appeared to be insufficient. Free-range areas generally lacked sufficient vegetation cover or artificial shelters, and chickens were predominantly observed ranging near the house. Further research should explore feasible ways for farmers to make key improvements to the indoor and outdoor environment, in order to improve broiler welfare.

Keywords: welfare; chicken; environmental enrichment; avoidance distance test; slow-growing; predation

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1. Introduction

One of the fundamentals of organic agriculture is animal welfare [1], which encompasses biological functioning and health, a natural life, and the subjective experience of the animal [2]. In order to promote animal welfare, with emphasis on species-specific behavioural needs, European Union (EU) regulations on organic animal production require e.g., lower stocking densities, at least 8 consecutive hours without artificial light for nocturnal rest and outdoor access for broilers [3]. The latter provides opportunities for important behaviours such as foraging and dust bathing. Although previous research indicates that only a small proportion of a flock uses the free-range areas provided [4–7], more recent findings based on individual tracking systems demonstrate dynamic ranging behaviour within flocks and indicate that in fact most birds range [8–10]. However, studies also show reluctance among birds to venture too far from the house [5,6,11], with some birds rarely or never entering the free-range area [12]. Vegetation cover and artificial shelters can encourage ranging in broilers [5,6,11,13], and one or the other must thus be provided in outdoor areas on organic farms [3,14].

Appropriate breeds should be used within organic production in order to promote animal health and well-being [15]. The rapid growth rate in fast-growing broilers, which is associated with severe welfare issues such as lameness, makes them unsuitable for the longer rearing period in organic production [16–18]. Consequently, these hybrids have on organic farms been replaced by more slower-growing broilers with e.g., improved leg health [16–20]. Combined with provision of environmental enrichment (EE) items on organic farms [14], this enables the more slower-growing birds to perform highly motivated and important poultry welfare behaviours [16,19], such as foraging, perching and dust bathing [21].

Swedish regulations, supported by EU organic regulations, allow a maximum average daily weight gain of 45 g for slower-growing hybrids [22]. The two slower-growing hybrids Rowan Ranger® [23] and Hubbard® [24] became commercially available in Sweden in 2014 and 2016, respectively. As a consequence, the number of organic broiler farms increased rapidly between 2015 and 2017, but only 1% of the total Swedish broiler production was organically certified by 2019 [25]. At the time of the study, organic broiler production in Sweden was hence a rather recent development, and knowledge of broiler welfare in the two aforementioned hybrids was limited. Much of the research reported on such hybrids (e.g., [4,6,13,16–20,26]) seems not to have been performed under commercial settings or under conditions compatible with those in Scandinavia. The aim of this study was thus to extend the limited knowledge of organic broiler behaviour, identify details of the free-range area and describe the present situation and practical solutions applied on organic broiler farms in Sweden.

2. Materials and Methods

The study did not involve any invasive treatment of the birds observed on commercial farms, merely behavioural observations, and therefore ethical approval by an ethics committee for animal experiments was not required under Swedish legislation [27].

2.1. Farms and Flocks

Eight organic broiler farms, all found in the southern third of Sweden, were visited during October (i.e., autumn) 2018. The farmers of all, at the time of the study, established organic broiler farms in Sweden (n = 12) were contacted by telephone and informed about the project, and thereafter asked to participate in the study. The farmers successfully contacted and consenting to participate were included and subsequently visited. All participating farms were certified according to KRAV® (Swedish organic incorporated association) standards [14]. Each farm was visited during one day, between 09.30–10.00 and 15.00–15.30, except one farm in which the visit commenced at 08.00 for logistical reasons. All farms were visited by the very same researcher (L.G.) and an assistant. One flock per farm was observed. The farm visits were performed as close to the time of slaughter as possible, and the broilers were on average 55 ± 6 (mean ± SD) days of age at the time. Rowan Ranger and Hubbard JA57/Hubbard JA87, both slower-growing hybrids, were reared in mixed-sex flocks on five and three farms, respectively. The former received eggs (Rowan Ranger) for on-farm hatching, while the latter received day-old (Hubbard) chicks. The chicks were kept in specific arrival compartments until around three weeks of age, when they were moved to a rearing compartment. Average flock size was 4217 ± 1290 and average farm size was 8975 ± 1688 (mean ± SD). Pop-holes connected the rearing compartment to a winter garden (a roofed platform with three walls and one wind net, littered floor and natural ventilation) from where the birds accessed the free-range area. On one farm, chickens were temporarily reared in eight formerly used mobile houses, due to ongoing reconstruction work in the otherwise used rearing compartments. On all farms, the birds were provided with roughage, objects to perch on, natural light inlets and at least eight consecutive hours of nocturnal rest, in accordance with current EU regulations [3] and KRAV® standards [14]. A more detailed description of the farms, flocks and housing can be found in a previous publication by our research group [28].

2.1.1. Farmer Interviews

During the farm visits, all farmers (i.e., bird caretakers) were interviewed according to a structured protocol (Appendix A) about management and husbandry routines, housing, bird health and behaviour (including free-ranging), productivity and free-range features.

2.1.2. Indoor Observations

Following the interview with the farmer, observations were performed in one broiler flock in one rearing compartment. The flock to observe, in case of two flocks of similar age, was selected by the farmer. The findings on housing system, indoor environment and bird health can be found in our previous publication [28].

An avoidance distance test (ADT) was performed according to the Welfare Quality® assessment protocol for poultry (WQ) [29] at each of the following five locations in the rearing compartment: entry door, adjacent water line in the centre of rearing compartment, centremost pop-hole, halfway along outer short side, and halfway along inner long side. The protocol used in the study also included number of birds touched (not included in the WQ). Observations were always made in this same order of locations when walking through the rearing compartment, and always at least five minutes after the observer had entered the compartment. The ADT was not continued if no chickens had been touched or counted at arm's length in these five trials, but was otherwise repeated 21 times in total. On the same five locations, the number of birds using the EE closest to the observer was recorded, along with a description of the EE object. The number of birds positioned on top of and adjacent (sitting or standing on the floor, including birds pecking at object, when applicable) to the EE item were counted.

Scan sampling of the behaviour (Table 1) of birds in and adjacent to (in direct contact with) the pop-holes was performed during five consecutive minutes. The number of birds observed performing different behaviours was recorded at three different pop-holes for each flock. During observations, the observer stood approximately 6 m away from the pop-holes to reduce the risk of affecting bird behaviour, while still having a clear view.

Table 1. Ethogram used for behavioural observations on Swedish organic broiler farms (modified from Rodriguez-Aurrekoetxea et al. (2015) [26] and Ventura et al. (2012) [30]).

Behaviour	Description
States	
Standing	Upright motionless position on extended legs with both feet, but no other body parts touching the ground during $\geq$2 s
Sitting	Positioned with bent legs, hocks resting on the ground and abdomen in contact with the ground
Resting	Positioned with sternum in contact with the ground, head lowered and resting on ground or tucked in under own wing, with eyes open, semi- or fully closed
Walking	Locomotion starting when bird takes two or more steps forward in succession
Perching	Bird standing, sitting or resting positioned on perch or other elevated structure
Foraging	Bird lowers its head and manipulates substrate on ground with beak and scratches with feet in search of food, while standing or slowly walking forward with head below rump level

Table 1. *Cont.*

Behaviour	Description
Eating	Bird with head above or in feeder, actively consuming feed
Drinking	Bird pecking at drinking nipple or consuming water from cup beneath drinking nipple
Events	
Preening	Manipulation (cleaning, arranging or oiling) of own feathers with beak, while standing or sitting
Dust bathing	Bird sitting or lying down in substrate, pecking and scratching at litter material, tossing and distributing loose substrate onto its back and wings, ruffling and shaking its feathers with or without rubbing head against ground
Wing stretching	Slowly extending one wing
Leg stretching	Slowly extending one leg backwards or laterally
Running	Rapid locomotion starting when bird takes two or more steps forward in rapid succession
Flying	Locomotion starting when bird extends and flaps wings and moves a distance through the air
Gentle feather pecking [1]	Bird uses beak to gently manipulate and lightly peck at feathers of recipient bird, which does not move away
Severe feather pecking [1]	Bird uses beak to forcefully manipulate feathers of recipient bird, which moves away from performer bird. Pecks are hard, fast and often singular and may result in detached feathers
Aggressive pecking [1]	Bird raises head and uses beak to forcefully stab at recipient bird, which moves away. Pecks usually directed towards the head, but may also be directed at the body
Fighting	Two birds standing facing each other, heads and necks raised to the same level, at least one bird forcefully kicking and pecking at conspecific
Pop-hole: walking along [2]	Bird walking in pop-hole parallel to its opening, at least three steps in succession
Pop-hole: turning back in [2]	Bird walking or running through pop-hole from inside towards outside, but making a halt and change of direction to remain indoors
Pop-hole: turning back out [2]	Bird walking or running through pop-hole from outside towards inside, but making a halt and change of direction to remain outdoors
Play-like activity [3]	Simulated fighting with jumping, kicking and pecking but without obvious aggression or forceful or injurious contact
Sparring [4]	
Frolicking [4]	Spontaneous burst of running and/or jumping with wings flapping, with no obvious intention, often with rapid direction changes
Food-running [4]	Bird picks up an object and runs with it in beak, often making peeping noises repeatedly, followed by at least one other bird
Vocalisations	Sudden loud, sharp, shrill, piercing cry
Squawks	
Other	All other abnormal, aberrant vocalisations

[1] From Daigle (2017) [31]. [2] Pop-hole observations only. [3] From Baxter et al. (2019) [32]. [4] Recorded as "play-like activity".

The behaviour of birds in groups inside the rearing compartment was continuously observed during five consecutive minutes. Observations were performed halfway along the inner long side of the house, while the observer was sitting down (Figure 1). For habituation, the observer sat for 5 min prior to these behavioural observations. The time from when the observer sat down until the first bird was within arm's length and the time until the first bird was touched, were recorded. The total number of birds within arm's length and the total number touched after 3 and 5 min were counted. For the subsequent behavioural observations, birds within an imaginary semi-circle with radius 5 m were included (Figure 1). State behaviours (i.e., behaviour patterns of relatively long duration [33]) were recorded as estimated proportion (%) of birds performing the behaviour (overall assessment for 5 min), while the number of birds observed performing event behaviours (i.e., behaviour patterns of relatively short duration [33]) was counted.

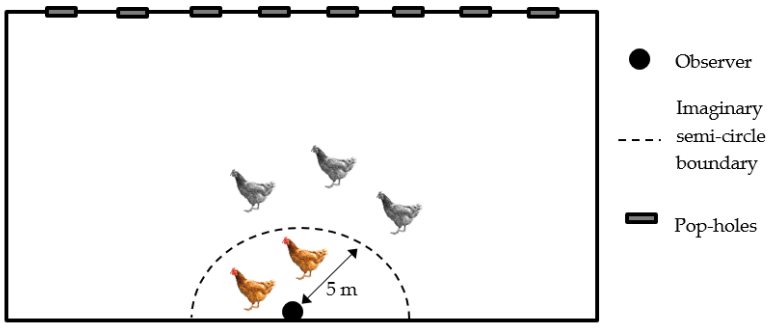

Figure 1. Schematic drawing of imaginary semi-circle boundary used for group behavioural observations of broiler chickens on organic farms.

2.1.3. Outdoor Observations

Outdoor observations were performed during the last part of the farm visits. From a position with a good overview, yet without disturbing the birds, the total number of chickens and the proportion of these ranging at certain distances from the winter garden were estimated (Table 2). The observation area did not include the winter garden.

Table 2. Protocol used for free-range observations (ranging behaviour and vegetation) on Swedish organic broiler chicken farms. Free-range area not including winter garden.

Observation	Description
Free-ranging	
Birds outdoors	Estimate of total number of birds in free-ranging area
Bird dispersion	Estimate of proportion (%) of total number of birds outside at <5, 5 < 10, 10 < 15, 15 < 25 and ≥25 m, respectively
Maximum distance	Longest distance from the winter garden to where a bird was observed ranging
Free-range features	
Pasture: proportion of total free-range area	0 (very low: <20%); 1 (low: 20 < 40%); 2 (moderate: 40 < 60%); 3 (high: 60 < 80%); 4 (very high: ≥80%)
Vegetation cover: proportion of total free-range area [1]	0 (none: 0%); 1 (extremely low: <5%); 2 (very low: 5 < 10%); 3 (low: 10 < 20%); 4 (moderate: 20 < 40%); 5 (high: 40 < 60%); 6 (very high: ≥60%)
Type of vegetation cover	Proportion (%) of total vegetation cover made up of bushes <100 cm, bushes ≥100 cm and trees, respectively
Artificial shelter	Description and number of objects, including dimensions as applicable, and an estimate of number of birds beneath

[1] Vegetation cover defined as bushes and trees >50 cm.

From a position with a good overview, a panoramic photograph was taken of the entire free-range area. Outdoor air temperature (°C) and humidity (%) were recorded at ground level. Precipitation (mm), wind speed and direction (m/s), and time of sunrise and sunset were recorded using a meteorological software mobile telephone application (Swedish Meteorological and Hydrological Institute, SMHI) [34].

2.2. Statistical Analyses

No indices were calculated according to The Welfare Quality® assessment protocol, which was used for scoring only. Microsoft Excel (2016) was used for data compilation and diagram creation. All statistical analyses were performed in R. Results are presented as mean and standard deviation for normally distributed variables, and as median and range for non-normally distributed count variables.

3. Results

3.1. Indoor Observations

3.1.1. Avoidance Distance Test (Fearfulness)

On the first seven farms visited, no chickens were touched or counted at arm's length in the five ADT trials at different locations in the rearing compartment, so the test was abandoned on these farms. On the eighth and final farm visited, two birds were touched and one bird was counted at arm's length in five ADT trials. During the five minutes of habituation prior to behavioural observations, no birds were touched on any of the farms. The median number of birds counted at arm's length was 1 (range 0–3) and 1.5 (range 0–7) after three and five minutes, respectively. The minimum time for a chicken to approach was on average 108 ± 98 (mean ± SD) seconds (one farm where no birds approached within five minutes excluded).

3.1.2. Behavioural Observations in Rearing Compartment

The average proportions of birds observed performing different state behaviours during behavioural observations in the rearing compartment are presented in Figure 2. The behaviour most commonly observed was sitting, followed by standing and walking. The numbers of birds observed performing different event behaviours are presented in Table 3.

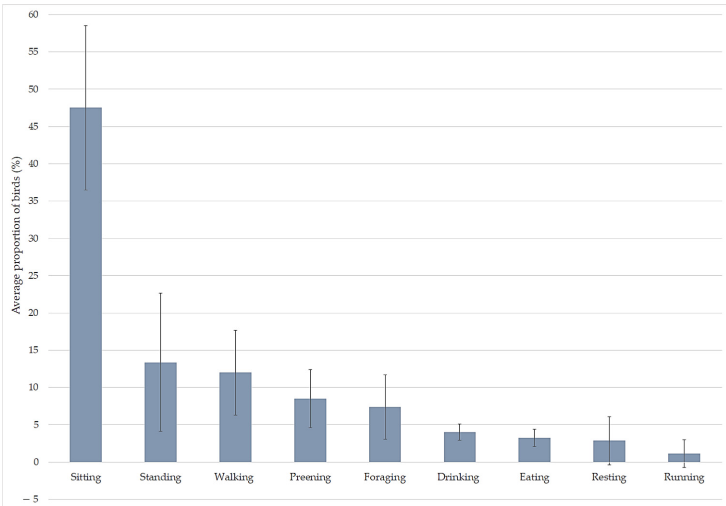

Figure 2. Average proportion of birds observed performing different state behaviours (mean ± SD) during behavioural observations (5 min per farm) on organic broiler farms (n = 8 farms).

Table 3. Total number and median of event behaviours observed during behavioural observations (5 min per farm) in the rearing compartment on organic broiler farms (*n* = 8), and total number of farms on which each event behaviour was observed.

Behaviour	Observations of Behaviour (Total Counts)	Observations of Behaviour (Median and Range) per Farm	Total Number of Farms on Which Behaviour Was Observed
Gentle feather pecking	10	1 (0–5)	5
Squawks	8	0 (0–7)	2
Leg stretching	6	1 (0–2)	5
Perching	4 [1]	1 (1–2)	3
Aggressive pecking	3	0 (0–2)	2
Wing stretching	2	0 (0–1)	2
Play-like activity	2	0 (0–2)	1
Fighting	1	0 (0–1)	1
Dust bathing	0	0 (0–0)	0
Flying	0	0 (0–0)	0
Other vocalisations	0	0 (0–0)	0
Severe feather pecking	0	0 (0–0)	0

[1] Perching on water and feed lines.

3.1.3. Environmental Enrichment

Environmental enrichment was provided on all farms, as reported by all farmers. On all farms but one, an assortment of different items intended as EE objects was observed in the rearing compartments during farm visits (Figure 3).

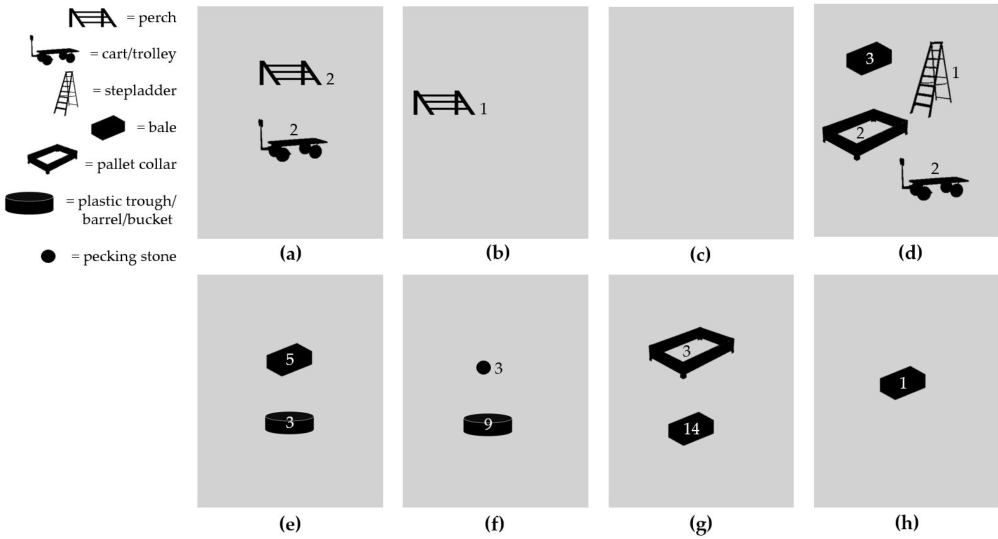

Figure 3. Schematic illustrations (note: not to scale) of environmental enrichment items observed on organic broiler farms (*n* = 8) in Sweden: (**a**) perches and trolleys; (**b**) perch; (**c**) no environmental enrichment; (**d**) Lucerne bales, pallet collars, stepladder and carts; (**e**) peat bales and plastic troughs with dust bathing substrate; (**f**) one plastic trough with dust bathing substrate and eight plastic troughs upside down; (**g**) straw bales and pallet collars with dust bathing substrate; (**h**) one large round straw bale.

Home-made wooden perches were provided on two farms (Figure 4). Total perch length was 21.6 m and 19.5 m, respectively, or 0.51 and 0.46 cm, respectively, per bird present in the house at the time of the visit.

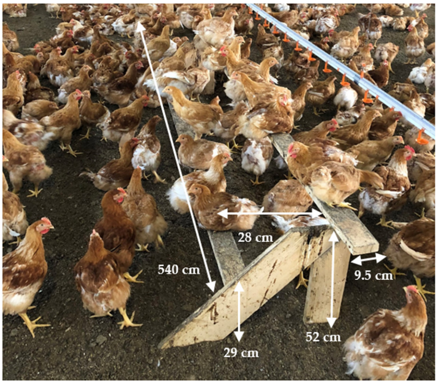

Figure 4. Two-tier home-made wooden perch observed on one organic broiler farm.

Numbers of observations of birds sitting or standing on and adjacent to the different items are presented in Table 4.

Table 4. Bird use of environmental enrichment items provided in the rearing compartment on organic broiler farms (*n* = 8): median number of birds on top and adjacent to item (unless only one observation per type of item) and total number of observations per type of item and farm.

Item	Number of Birds on Top of Item per Observation (Median and Range)	Number of Birds Adjacent to Item per Observation (Median and Range)	Total Number of Observations per Item	Number of Farms on Which Observations Were Performed (out of Total Farms Possible)
Perches [1]	16 (13–21)	n/a	10	2 (2)
Cart [2]	15	18	1	1 (2)
Pallet collar [3]	7 (1–13)	7.5 (5–10)	2	2 (2)
Straw bale (large, round)	6 (4–8)	25 [6]	4	1 (1)
Bales (small, square) [4]	4 (0–6)	6 (2–11)	9	3 (3)
Plastic barrel upside down [5]	2 (1–4)	9 (0–12)	5	1 (2)
Plastic bucket upside down	1	3	1	1 (1)
Eight steps-stepladder	0	4	1	1 (1)

[1] Total length 21.6 m and 19.5 m, respectively. [2] Surface area ~1.5 m^2. [3] On top = on pallet edge. [4] Straw, peat and lucerne. [5] Surface area ~0.4–1.4 m^2. [6] Not possible to count exact number (i.e., estimate).

3.1.4. Behavioural Observations at Pop-Holes

The average width of the pop-holes was 170 ± 34 cm and the average height was 46 ± 8 cm (mean ± SD). The numbers of birds observed performing different behaviours at the pop-holes during behavioural observations are presented in Table 5. The behaviours most commonly observed were standing, sitting and foraging.

Table 5. Total and median number of behaviours observed (per pop-hole and per farm) during group behavioural observations (5 min per pop-hole) at pop-holes (n = 23) on organic broiler farms (n = 8) and median number of observations per meter (width) pop-hole.

Behaviour	Observations of Behaviour (Total Counts)	Total Number of Pop-Holes at Which Behaviour Was Observed	Observations of Behaviour (Median and Range) per Pop-Hole	Total Number of Farms on Which Behaviour Was Observed	Observations of Behaviour (Median and Range) per Farm	Observations of Behaviour (Median and Range) per Meter (Width) Pop-Hole
Standing	243	22	10 (0–23)	8	23.5 (5–58)	6.5 (0–13.9
Sitting	108	19	3 (0–16)	8	7.5 (1–39)	1.5 (0–8)
Foraging	90	17	2 (0–14)	7	7 (0–31)	1.2 (0–8.5)
Preening	47	13	1 (0–8)	7	3.5 (0–13)	0.6 (0–4.9)
Turning back in	21	10	0 (0–7)	7	1.5 (0–9)	0 (0–3.5)
Running	20	8	0 (0–6)	5	1 (0–8)	0 (0–3)
Leg stretching	15	9	0 (0–3)	6	1.5 (0–5)	0 (0–1.5)
Walking (along pop-hole)	11	5	0 (0–3)	3	0 (0–5)	0 (0–1.8)
Gentle feather pecking	10	4	0 (0–5)	4	0.5 (0–5)	0 (0–2.5)
Wing stretching	6	6	0 (0–1)	5	1 (0–2)	0 (0–1)
Turning back out	6	6	0 (0–1)	3	0 (0–2)	0 (0–1)
Aggressive pecking	2	2	0 (0–1)	2	0 (0–1)	0 (0–0.6)
Dust bathing	2	2	0 (0–1)	2	0 (0–1)	0 (0–0.6)
Resting	1	1	0 (0–1)	1	0 (0–1)	0 (0–0.5)
Flying	0	0	0 (0–0)	0	0 (0–0)	0 (0–0)
Severe feather pecking	0	0	0 (0–0)	0	0 (0–0)	0 (0–0)
Fighting	0	0	0 (0–0)	0	0 (0–0)	0 (0–0)
Play-like activity	0	0	0 (0–0)	0	0 (0–0)	0 (0–0)

3.2. Outdoor Observations

The chickens were allowed outdoor access at around 23–30 days of age. Most commonly, the chickens had access to the winter garden only during the first 1–2 days. Thereafter, they could typically access the outdoor area from 07.30–08.30 h until darkness. Continuous (i.e., also during the night) access to the free-range or winter garden was however provided in summertime on one and three of the farms, respectively. Free-range access was weather-dependent throughout the year on all farms, and typically provided from spring (March–May) until autumn (September–November). The pop-holes were normally open and the winter garden accessible to the chickens when outdoor temperature was above 0 °C. All flocks had access to the free-range during farm visits.

3.2.1. Free-Range Features

The free-range areas on most farms consisted mainly of pasture, with little or no vegetation cover (Figure 5). Vegetation cover was typically restricted to a particular area of the range. The free-range areas comprised natural (not planted) vegetation on all farms. In general, farmer interviews revealed reluctance to plant trees or bushes, since it would hamper pasture topping or crop production. However, two farmers had considered planting currant and blueberry bushes, respectively. Artificial shelters were provided on five farms (Figure 5), typically within 25 m from the winter garden.

3.2.2. Free-Ranging Behaviour in Chickens

Outdoor observations were performed at 14.00–15.30 on seven farms and at 08.00 on one farm. Time of sunrise and sunset was 06.58 h and 19.03 h, respectively, when visiting the first farm, and 07.56 and 17.42, respectively, when visiting the last farm. The estimated number of chickens observed ranging, along with current weather conditions, are presented in Table 6. On all farms but one, the maximum distance from the winter garden to where a bird was observed corresponded to the point at which there was no more artificial shelters or vegetation cover. Farmers estimated the maximum distance birds ranged from the winter garden to be 50–65 m (seven farms) and 150 m (one farm).

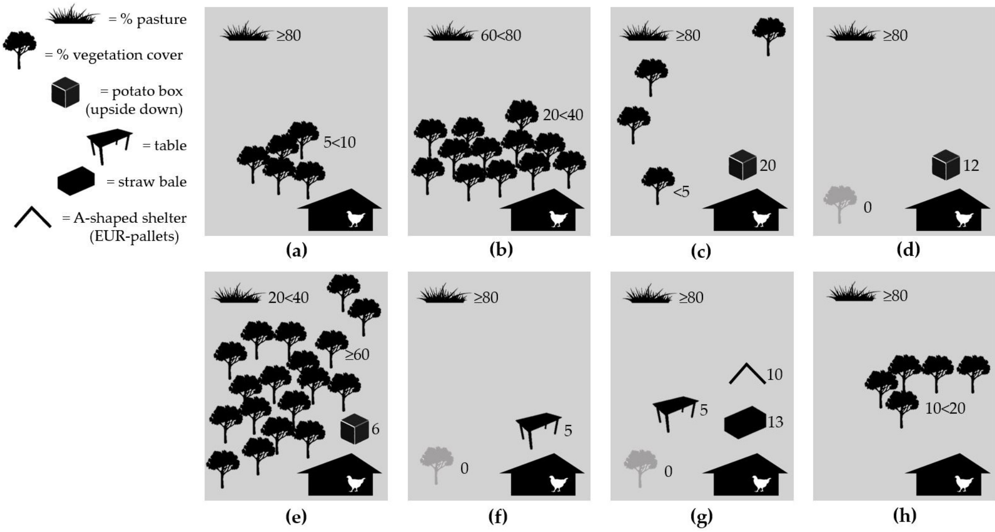

Figure 5. Schematic illustrations (note: not to scale) of vegetation dispersion and artificial shelters (AS) in free-range areas on organic broiler farms (n = 8) in Sweden: (**a**) one single distinct area with trees and bushes within 55 m from winter garden; (**b**) population of trees and bushes without clear boundary within 65 m from winter garden; (**c**) six distinct areas (single trees and occasional bushes) distributed throughout the free-range. Total AS overhead cover area 24.6 m^2; (**d**) pasture only. Total AS overhead cover area 14.4 m^2; (**e**) trees and bushes distributed throughout the range (difficult to get a clear view of the entire range). Total AS overhead cover area 7.5 m^2; (**f**) pasture only. Total AS overhead cover area 15 m^2; (**g**) pasture only. Total AS overhead cover area 28.2 m^2; (**h**) one single distinct area with trees and bushes within approximately 50 m from house.

Table 6. Proportion of broiler flocks observed free-ranging (FR) on Swedish organic chicken farms (n = 8), distance from winter garden and prevailing weather conditions (HR: heavy rain; D: drizzle; S: sunny; C: cloudy).

Farm	Proportion % of Flock FR [1]	Distance (m) from Winter Garden (% of FR Chickens)					Maximum Distance (m) from Winter Garden	Temperature (°C)	Cloud cover	Precipitation	Average Wind Speed [2] (m/s)
		<5	5 < 10	10 < 15	15 < 25	≥25					
a	6 (250)	10	10	20	55	5	55	10.2	S	-	5 (9)
b	0 (0)	n/a	n/a	n/a	n/a	n/a	n/a	7.5	C	HR	5 (9)
c	0.2 (8)	37.5	0	0	62.5	0	19	12.2	C	D	6 (14)
d	1.1 (50)	20	60	10	10	0	18	16.8	S(C)	-	4 (8)
e	3.3 (160)	12.5	31.3	37.5	12.5	6.3	33	12.2	S	-	5 (10)
f	0 (0)	n/a	n/a	n/a	n/a	n/a	n/a	8.3	S	-	5 (13)
g	0.8 (40)	12.5	50	12.5	25	0	16	9.5	S	-	6 (14)
h [3]	21.5 (215)	70	9.3	4.7	7	9.3	40	8.6	C	D	9 (19)

[1] Absolute numbers in brackets. [2] Gusts (m/s) within brackets. [3] Observations performed at 08.00 h.

3.2.3. Predation

Three farmers considered ground and/or aerial predators to be a significant problem. Foxes (*Vulpes vulpes*), badgers (*Meles meles*) and birds of prey were mentioned specifically. Two farmers reported occasional problems with aerial predators in particular only. The remaining three farmers reported none or minor problems with ground and/or aerial predators. In terms of fencing as a measure to exclude ground predators, there were large differences between the farms (Table 7).

Table 7. Description of fences around free-range areas on organic broiler farms (n = 8) in Sweden.

Farm	Description of Fence
a	Chicken wire (height 100 cm); buried 30 cm horizontally underground; slacking considerably in places
b	Sheep fence (height 100 cm); square openings 10–12 cm; slacking considerably in places
c	Wildlife fence (180–200 cm); ground-level electric fence
d	Sheep fence (100 cm); square openings 10–12 cm; slacking considerably in places; not enclosing entire range
e	Wildlife fence (180–200 cm)
f	Robust wildlife fence (155 cm); mink-proof fence bottom 100 cm, buried 20 cm underground; electric fence at top and ground level
g	Wildlife fence (180–200 cm)
h	Robust wire fence (height ~150 cm)

4. Discussion

4.1. Indoor Observations

4.1.1. Avoidance Distance Test (Fearfulness)

No chickens were touched or counted at arm's length in five ADT trials on seven farms, which may reflect a general fearfulness of humans or specific fearfulness of an unfamiliar human wearing unfamiliar clothing [35,36]. The test was likely not biased by poor leg health [37] or high stocking density [38], biases previously described in studies on fast-growing broilers in conventional production and in experimental conditions, respectively. Most birds (94%) assessed were observed to have no or minor gait impairments (see [28]), and were thus able to distance themselves from the observer. Bird density during farm visits was 17.1 $\pm$ 1.9 kg (mean $\pm$ SD) per m^2 (see [28]) and allowed birds to move away without obstruction.

On the eighth farm visited, two birds were touched and one bird was counted at arm's length in five ADT trials. No more trials were performed, since no more than five trials per flock had been completed on the preceding farms. On the eighth farm, the birds were kept in relatively small mobile houses. This possibly explains why they were less fearful, since in a smaller compartment the distance between farmer and birds at any one time decreases, and visual contact presumably increases, which has been shown to improve the human–bird relationship and reduce chicken fearfulness [39].

The average minimum time for a chicken to approach the observer during the habituation period prior to behavioural observations was almost two minutes. During the ADT trials, the observer squatted for only 10 s, according to the WQ protocol, which appears to have been insufficient time for the chickens to begin to approach.

4.1.2. Behaviour in Rearing Compartment

Sitting was the most common behaviour observed, performed by on average almost 50% of the birds included in the group observations. Most farms were visited near the time of slaughter, and thus body weight and stocking density [17] might explain this inactivity, as slower-growing hybrids also become less active with age [16,19,20]. Although relatively slower-growing hybrids spend less time sitting and inactive in comparison with fast-growing strains [16,17,20], it is important to emphasise that the broilers in this study had average daily weight gain of 45–50 g (see [28]). Thus, as previously noted [18], this growth rate might not have been slow enough to alleviate the effect of weight on chicken behaviour. Furthermore, although no severe lameness was observed, only 23% of the chickens walked without any gait impairment (see [28]). The large proportion of birds observed sitting in this study may partly be explained by minor gait impairments, a correlation recently demonstrated in fast-growing broilers [40].

Foraging, which was performed by less than 10% of the birds observed, has also been shown to decrease with age in both fast- and slower-growing hybrids [16,17,19]. The adult red junglefowl (*Gallus gallus*) spends around 60% of its active time foraging [21], while the corresponding time allocated in 9-week-old slower-growing broilers is reported to be less than 5% [16,17]. Foraging is an important species-specific behaviour and, although broilers in commercial production are not required to forage to the same extent as their ancestor in the wild in order to meet their nutritional needs, the relatively small time broilers spend foraging in comparison should be noted. It might be explained by increasing body weight hampering active behaviours [17], but also by poor litter quality, which was observed on some of the farms (see [28]). Although free-ranging provides increased foraging opportunities, it is important that good litter quality is maintained indoors, especially during wintertime when the birds do not have outdoor access.

Preening, an important comfort behaviour in poultry, was performed by on average 8.5% of the birds observed. Adult red junglefowl spend around 12% of their active time preening [21], but slower-growing broilers have been reported to allocate less than a third of this to preening at 9 weeks of age [17]. The sampling method used in this study did not allow for evaluation of time budgets, but the results indicate that the environment on the farms allowed for comfort behaviours (on the floor) to be performed in a synchronised manner, which is important to poultry [41]. Other comfort behaviours, such as dust bathing, leg and wing stretching and play behaviours, were rarely or never observed, however. The sampling method used and the limited time of recording were likely insufficient [33] to detect any e.g., stretching [42] or play behaviour [32]. Moreover, observations were performed around noon on all farms but one (where observations were performed around 09.00), and it is possible that the time of day reduced the chances of observing these behaviours [17,40,42]. However, the results are in agreement with previous findings for slower-growing hybrids [16,19], and other possible explanations for e.g., the lack of observed dust bathing include poor litter quality [19]. Wood shavings were predominantly used as litter (see [28]), and might have been an undesirable type of dust bathing substrate [43,44]. Further studies are necessary to gain a more profound understanding of the behavioural repertoire and time budgets in these two slower-growing broiler hybrids in a commercial environment.

4.1.3. Environmental Enrichment

The chickens in this study were provided with a variety of different types of EE items. The on-farm observations indicated that providing broilers with EE does not have to be particularly complicated or expensive. However, it is important that the items provided are suitable for the purpose and meet the behavioural needs of chickens [45]. Some of the EE observed, e.g., perches and a cart, were frequently used by the birds. Others, such as a stepladder, were not. Straw bales provided a structure for the broilers to sit on top of and also foraging opportunities, in agreement with previous findings [19]. Chickens were commonly observed tightly clustered around the EE items, which suggests, in agreement with previous studies [19,46], that the chickens used these items as shelter while resting. However, chickens gathering around the EE might also indicate an insufficient space allowance per bird on top of these items. For instance, perch length was approximately 5 m/1000 birds, or 0.5 cm per bird, compared with 18 cm and 20 cm perch per bird required for laying hens and guinea fowl, respectively [3]. This can negatively affect bird welfare, since it is important that perching can be performed synchronised [41], especially during night-time. Chickens were also observed perching on items not primarily intended for perching but, for example, for dust bathing (e.g., plastic troughs or pallet collars), and feed and water lines. This confirms that these slower-growing broilers are both motivated and physically capable of perching [17,20]. Several studies have evaluated the suitability of different items as EE for broilers (for review, see [47]), but research investigating the optimal amounts or distribution is still needed. Furthermore, no minimum requirements on EE quantity are specified in the standards which require organic broilers in Sweden to have access to such structures [14]. The provision of EE must be predominantly based on the behavioural needs of chickens, but for such measures to be implemented these must also be practically and economically feasible for farmers.

4.1.4. Behaviour at Pop-Holes

The most common behaviour observed at the pop-holes was standing, followed by sitting. Chickens thus seemed to appreciate this position between the outdoor and indoor environments. Previous studies on laying hens have also found that some birds commonly remain sitting in the pop-holes [48,49]. On four of the farms, the pop-holes were quite crowded with birds. This appeared to correlate to (although no statistical analysis was possible) a difference in elevation (range 10–19 cm) between the floor of the rearing compartment and the pop-hole, creating a raised threshold for chickens to ascend. On farms where there was no such raised threshold, the pop-holes were not as crowded. Birds perching in the pop-holes could cause crowding [49], and observations of agonistic behaviours might thus be expected. However, aggressive pecking and fighting were rarely and never observed, respectively, at the pop-holes, in agreement with previous findings for laying hens [50]. These observations may indicate that pop-holes have the potential for inherent value, not only as an entry or exit but for the birds both to make a functional choice and express motivated behaviours.

4.2. Outdoor Observations

4.2.1. Chicken Free-Ranging and Free-Range Features

The proportion of chickens observed ranging at the time of the visit was low in all flocks. On seven of the farms, less than 6% of the flock was observed in the outdoor area. This is in agreement with findings in previous (though predominantly experimental) studies on both fast- [5,7] and slower-growing broilers [4,6] showing that only a small proportion of the flock ranges at any one time. However, individual tracking systems have shown bird ranging to be highly dynamic within a flock throughout the day [8,10]. Thus, counting the number of birds on the free-range area at a particular point in time provides limited information about range use within a flock and throughout the day. Weather conditions might have affected chicken ranging [5,13,48] in this study. In two flocks no chickens were observed outdoors, likely due to heavy rain during one farm visit and windy weather (in addition to no vegetation cover and scanty artificial shelter) during the other [48,51].

On the eighth farm, approximately one-fifth of the flock was seen ranging. Observations on this flock were performed in the morning (as opposed to early afternoon on the other farms) due to logistics, and the flock was considerably smaller in size than the other flocks observed. Both are factors which could account for the larger proportion of birds ranging on this farm [4–7,10].

The broilers in this study might have been discouraged from ranging due to generally limited protective cover from vegetation and artificial shelters. On four farms, the observed free-range areas contained no vegetation cover, or trees and bushes only sparsely scattered throughout the range. Trees and bushes covered one-fifth or more of the entire free-range area on only two farms. Previous research has shown that natural vegetation cover attracts broilers onto the free-range area [5,11,13], and in fact the three flocks with a higher proportion of chickens ranging had a free-range area with relatively more vegetation cover and the majority of ranging chickens were observed in these areas. Although farmers in general were reluctant to plant trees or bushes, two farmers did consider planting (currant and blueberry bushes, respectively). Such integrated production systems could benefit chickens and farmers, providing the former with protection and the latter with additional income.

Artificial shelters were provided in five of the free-range areas studied, of which four contained no or minimal vegetation cover. However, the total overhead artificial shelter area was limited (at most 28 m^2). Artificial shelters may encourage ranging in broilers [6], but the number of chickens ranging was too low to evaluate any such effects of the items provided in this study. The effects of similar structures on bird ranging have been studied previously [6,13,51,52], but predominantly in laying hens, and without evident or consistent results. To reach the artificial shelters, the chickens commonly had to cross a barren area adjacent to the winter garden. It has been suggested that this distance, where birds are exposed to, e.g., aerial predators, might undermine the effect of artificial shelters [53].

The maximum distance from the house to where at least one chicken was observed ranging was 55 m and, on all farms but one, this distance corresponded to the point where there was no more vegetation cover or artificial shelter. This, and similar findings in previous studies demonstrating reluctance of birds to venture too far from the house [5,6,11], emphasise the importance of providing protective structures in free-range areas. The artificial shelters on farms in the present study were commonly placed no farther than 25 m from the winter garden, which was typically as far as any broiler was observed in free-range areas providing artificial shelter only. Thus, a more even distribution of artificial shelters might encourage these broilers to explore larger areas of the free-range [52,54]. Further studies are needed to investigate this in terms of how to successfully encourage broiler ranging.

4.2.2. Predation

Three farmers considered ground predators to be a significant problem. On two of these farms, fences were slack and clearly did not protect against e.g., foxes. Only two farmers reported no problems with ground predators, and theirs were the only farms on which wildlife fences were complemented by an electric fence. However, on one farm the free-range area was not completely enclosed but the farmer did not consider ground predators to be a major problem. It should be emphasised that predator issues were defined in terms of the farmer's perception, rather than based on information on flock mortality. Thus it must be taken into account that there are likely differences between individual farmers regarding what are considered no, small or severe problems. Nevertheless, since the primary function of the fences is not to keep animals in, but to keep predators out, free-range areas must be equipped with fences suitable for the purpose in order to mitigate what currently poses an important animal welfare issue in free-range poultry systems [55].

4.3. Limitations of the Study

At the time of the study, the eight farms included represented two-thirds of the total number of commercial organic broiler farms in Sweden, to the best of our knowledge. Of the remaining four farms (not included in the study), one declined when asked to participate and three were unsuccessfully contacted. Due to the limited number of farms, it was not possible to separate e.g., the effect of hybrid from other specific farm-related factors. This also created difficulties in analysing e.g., the effect of EE on bird behaviour, due to the uniqueness of EE items used on each farm. The flock to be observed, in the case of two flocks of the same age, was chosen by the farmer. This potential bias could have been avoided by using a simple method for randomisation. The flocks were to be observed as close to the time for slaughter as possible, yet the autumn weather still allowed them to have outdoor access, which led to an age variation between some of the flocks. Ideally farm visits would have been performed around similar ages in all flocks. Farm visits were limited to one day on each farm. Behaviours that are affected by e.g., time of day and current weather conditions are thus difficult to extrapolate further. Repeated observations within a flock and in more than one flock per farm, while not possible in this study due to time limitations and for logistical reasons, would have enabled more profound conclusions to be drawn. However, despite the lack of repeated observations, the results from the bird observations and from farmer interviews provide novel insights into organic broiler production on Swedish farms.

5. Conclusions

There is a limited number of on-farm studies of slower-growing broilers in organic production available. This study extended existing knowledge and provided a first, although limited, overview of bird behaviour in two slower-growing hybrids in commercial settings and of the free-range areas on organic broiler farms in Sweden. Behavioural observations showed that even at the very end of their production cycle, the more slower-growing hybrids were agile enough to distance themselves from unknown humans and to ascend various objects for perching. However, a large proportion of the birds were observed in a sitting posture on the floor, indicating that attention should be paid to the effect of current growth rate on the behaviour of these slower-growing broilers. Birds were highly motivated to perch and were provided with a wide variety of items to sit upon, but the quantities of items and space for perching appeared insufficient. In general, the free-range areas lacked sufficient vegetation cover or artificial shelter, and chickens were mainly observed ranging close to the house. Future research should thus aim at identifying key improvements to the indoor and outdoor environment that meet the behavioural needs of the chickens and are also feasible for farmers to implement, in order to increase animal welfare, which is one of the fundamentals of organic animal farming.

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Institutional Review Board Statement: The study did not involve any invasive treatment of the birds, and therefore ethical approval by an ethics committee for animal experiments was not required under Swedish legislation.

Data Availability Statement: Restrictions apply to the availability of these data. The data presented in this study is available on request from the corresponding author, with the permission of the participating farmers.

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Appendix A

Table A1. Questionnaire used in interviews with farmers on Swedish organic broiler chicken farms.

Questions		
General information	Hybrid	Rowan Ranger ☐ Hubbard ☐ Other:
	Organic production	Since year: Conventional before: ☐ Yes ☐ No If yes, since year:
	Buildings	New ☐ Rebuilt ☐ Maximum capacity (number of birds): Same number of birds winter-/summertime: ☐ Yes ☐ No

Table A1. *Cont.*

Questions		
General information	Observed flock	Current age: Original number of birds: Current number of birds: Current average body weight:
Hatching and young chicks	Hatching	On-farm ☐ or day-old chicks ☐ If on-farm hatching, brooding days: Name of hatchery: Distance transported:
	Arrival rooms	☐ Yes ☐ No If yes, age when moved to rearing room: If yes, method for moving to rearing room:
	Indoor environment	Temperature scheme (°C): Natural light: ☐ Yes ☐ No Artificial light scheme (hours):
	Medical treatments	Vaccinations: ☐ Yes ☐ No If yes, what: Other medical treatments: ☐ Yes ☐ No If yes, what:
	Critical points	☐ Yes ☐ No If yes, age(s) or phase(s): Measures of prevention:
Housing (rearing compartment)	Indoor environment	Temperature (°C): Natural (N) light: ☐ Yes ☐ No Artificial (A) light type: Night time (A) (hours): Dusk and dawn simulated (A): ☐ Yes ☐ No If yes, time/duration: Litter type: Underfloor heating: ☐ Yes ☐ No
	Air quality	Ventilation type: Ammonia monitoring: Ammonia regulation:
	Environmental enrichment	Object(s): Amount/number: Distribution: Time of year provided: Age of installation:
	Roughage	Type(s): Supplier: Amount: Distribution: Time of year provided:
Production	Mortality	This flock (%): Average (%): Main reasons:
	Culling	Average number of birds: Main reasons:
	Hatching	% of eggs discarded/not hatched:

Table A1. *Cont.*

Questions		
Production	Slaughter	Thinning: ☐ Yes ☐ No Age(s): Abattoir: Distance transported: Harvesting: Trained team ☐ Selves ☐ Comments on harvesting:
	Growth	Expected average slaughter weight: Average daily weight gain: Feed conversion rate:
	Feed specifics	Supplier: Starter (type and age period): Rearing (type and age period): Finisher: (type and age period):
Outdoor area	Free-range access (pop-holes/curtain open)	From age: Hours per day: Months per year: Weather conditions:
	Birds' free-ranging behaviour	Age when first ranging: Weather conditions preferred by chickens: Weather conditions disliked by chickens: Average distance from house (m): Maximum distance from house (m):
	Predators	Problem: ☐ Yes ☐ No If yes, what species: Measures of prevention:
	Free-range characteristics	Area: Vegetation: Natural ☐ Planted ☐

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High animal welfare standards are fundamental in organic agriculture. In this thesis, on-farm studies were performed on organic broiler farms and organic laying hen farms in Sweden, to assess animal welfare in terms of housing, bird health and behaviour, outdoor access and free-ranging. The results contribute with knowledge about the present welfare situation in commercial poultry production and about welfare issues that need to be addressed in the future.

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