Soil Association

Welfare implications of range and flock size: A review of the literature

Summary

Access to the pasture has always been a fundamental organic principle of poultry production and our standards have always required it. However, there is significant scope to increase the birds' use of the range and evidence to suggest that it has substantial benefits for welfare. These include reduced incidence of injurious feather pecking, improved leg health in broilers and the supplementation of their diet through foraging. Studies into ranging behaviour have yielded a number of management techniques to improve the functioning of the pasture and increase the birds' use of their outdoor area.

Scientific evidence and opinion appears divided on the specific effect of flock size on welfare in poultry. Benefits (e.g. ability for better inspection of all birds, easier access to range) and risks (e.g. higher aggression, competition for resources) associated with smaller flock sizes have been recorded. Investigations into flock size are often confounded by differences in total space available, stocking density and range quality, which are thought to have a larger impact on bird behaviour than flock size. The overriding impact on welfare appears to be the management of all the factors within the system by the stockperson.

Access to pasture and range

Birds having every day access to the pasture has always been a fundamental organic principle and our standards have always required it. However in practice, in a lot of instances, birds are not using the range as we would expect them to. This could be for a number of reasons.

1. The quality of the range – not enough shelter or not adequately distributed; uninteresting pasture; insufficient vegetation.
2. Birds are not encouraged to use it – not introduced to the range at an early age.
3. Licensees can be disillusioned from encouraging the use of the range if they cannot get it work at first. If it is not working correctly it can lead to problems of over-use near to the houses causing build-up of manure, over-grazing of the sward, compaction and increase of parasite/disease risk

Our standards should require that birds have regular access to a properly functioning range/pasture to help meet the five freedoms:

Freedom from hunger and thirst – the range can provide a varied and alternative part of the daily ration with unrestricted access for all the flock
Freedom from discomfort – provides a more open and spacious environment for birds who want to get away from other birds to avoid bullying and aggression and take advantage of the weather to adapt their own environment – for example use shade and breeze on a hot day.
Freedom from pain, injury and disease - flocks that use the outdoor access have less injurous feather pecking (IFP). It can be a relief from red mites and other parasites (less risk of bone damage?)
Freedom to express normal behaviour – the range provides for dust bathing, sunbathing, foraging, environmental enrichment to investigate
Freedom from fear and distress - enables birds to get away from bullying and aggression and provides more personal space

Supporting evidence from recent publications

- **A higher proportion of birds ranging reduces injurious feather pecking** (Bright et al (2011); Van de Weerd et al (2009) and several other papers taken from Pickett (2009) including:
    - Green *et al* (2000) found that, where less than 50 per cent of the flock use the outdoor area on a fine sunny day, this was a significant risk factor for feather pecking. Nicol *et al* (2003) found that the risk of feather pecking was reduced nine-fold in flocks where more than 20 per cent of birds used the range on sunny days.
    - Free range organic flocks that spend more time outside are generally healthier, more productive and better feathered than those that do not range well (Bestman and Keppler, 2005).
      The risk of feather pecking in organic flocks was found to increase when less than 66% of the flock used the range (Bestman and Wagenaar, 2003).

- **A range area can also stimulate increased activity for organic broilers thereby improving leg health** (Rodenburg et al., 2004).

- **The range can supplement organic rations** (Basset, 2008;, Van de Weerd et al, 2009; Dinnage, 2009) with varying suggestions - up to 70% of their requirements for lysine and methionine and approximately 25% of their requirements for calcium. (Merritt et al, 2010), 25% lysine, methionine and calcium (Horsted, 2006), range provides less than 5% of nutrition in summer (Dinnage, 2009)

Examples of good practice and concerns from research/other schemes

Good practice

- More tree cover leads to more birds ranging and ranging further (Bright et al, 2011; Van de Weerd et al, 2009) – needs to be mature trees
- Smaller flock sizes encourage range use. (BFFP, 2010)
- Lower stocking density indoors increases range use (BFFP, 2010)
- More canopy cover leads to less plumage damage by end of lay (Bright et al, 2011)
- Variation in type of shade – prefer dappled for resting and preening, open for foraging and dust-bathing (Bright et al 2011 and others)
- Increase the number of artificial structures providing shade on the range. (BFFP,2010)
- Increase the amount of vegetation on the range (this could be combined with an increase in foraging behaviour if vegetation is of a sort that birds will forage in e.g. herbs). Alternatively profit making crops, such as cider apples, could be planted.
- Keep other animals on the range, as these tend to attract the hens out further and to utilise more of the range (also help prevent predation and support clean grazing)
- Housing cockerels on the range (and help prevent predation)
- Reducing the number of chain feeder runs each day by avoiding running them in the middle of the day, as this tends to "call them in off the range".
- Earlier access to the range increases the number of birds on the range and reduces IFP (BFFP, 2010)
- Early access to the range allows build-up of immunity for layers
- Earlier access to the range increases use of range e.g. layers from 6 weeks, broilers whilst still under heat from 1 week in the summer (Merritt et al, 2010)
- Purchasing birds at an earlier age (or allowing range access on the rearing farm).
- Appropriate breeds – for example Hubbard and Sasso for broilers
- Other benefits of tree planting – soil stabilization, prevent nutrient leaching and carbon sequestration

- Pop hole size and access – wide and tall enough to allow 2 birds to pass and evenly dispersed around the building so that all birds have easy access.

Issues to be aware of:

- Seasonal variation in preference to range: layers – autumn, broilers – summer and autumn, both range less on windy and rainy days (Bright et al, 2011)
- Verandas are not part of the outside range – need to be clear that pop holes relate to access to outside
- It should be noted that producers must be careful to manage the risk of earlier range access causing an earlier onset of lay (which is associated with vent pecking). Allowing limited range access i.e. for a few hours in the afternoon may be a means of achieving this.
- White breeds more susceptible to predation
- Drinking from puddles – transmission of infectious diseases
- A range of studies of non-organic broilers show only 12 – 23% were ranging and 45% of FYM is deposited within 20 m of house – risk of leaching and build-up of N plus build-up of parasite burden but studies of smaller organic flocks show: 700 birds – 35%, <500 birds - 40% , >1500 birds – 5 to10%, however on a range with good cover 2000 birds – 75% (Van de Weerd et al 2009)

RSPCA guidance on the getting the optimum use from the range (RSPCA, 2011) **:**

- Provision of natural cover such as trees, bushes and hedgerows
- Provision of a variety of types of both natural and artificial shade/shelters
- Appropriate distribution of shade/shelter and natural cover depending on the behaviour of the individual flock and distance hens are comfortable travelling between sources of overhead cover
- Provision of a 'corridor' of shade/shelter and natural cover to encourage birds onto the range
- Rotation of any artificial shade/shelters
- Provision of well-managed areas of enrichment and variation, which may include suitable feed crops, herbs, trees and fruit bushes
- Provision of well-managed designated areas with additional facilities for dustbathing, perching and foraging, such as brashings from trees and covered sand areas
- Practice of paddock rotation to promote range quality
- Restricted access to muddy/poached/worn areas to allow re-growth of vegetation
- Drainage improvements to prevent poached areas developing
- Particular attention being paid to the area immediately outside the popholes and up to about 30m from the popholes
- Surface tilling of the land to help remove worm eggs
- Introduction of other species such as llamas and alpacas where appropriate, which can help to encourage birds outside and protect against predators
- Situating popholes on more than one side of the house, which can be of particular importance in units with central nest boxes.

The following are all from the IOTA organic poultry management review of literature (Dinnage, 2009 and Kelly, 2009)

- Recommendation of resting for 1 or even 2 years for efficient endoparasite control (Van de Weerd, et al 2009)
- Outdoor and extensive production systems have specific health and disease implications. Animals selected for high production efficiency are more at risk for behavioural, physio-biological and immunological responses.
- Pasture usage is encouraged by early access but parasite build-up may be higher; control methods will be needed.
- Conifer wig-wams are attractive to chickens and they will follow them around a pasture; they can be used to distribute droppings within the paddock.

- Control of internal parasites, in particular coccidiosis, is a possible problem in free-range systems that do not have feed rations containing prophylactic medications. It is thought not to be a likely problem in adult birds that have acquired immunity as long as hygiene standards are good, stocking densities are not too high and site rotation is practised.
- Helminths are more common in outdoor birds. Paddock rotation, keeping grass short, avoiding reused litter, housing ages separately, and pasture harrowing are essential.
- Wild birds carry fowl cholera, and Newcastle disease so outdoor flocks are at risk.
- Monitoring for pullorum disease is essential because it can be vertically passed to chicks.
- Feed, wild birds, rodents and possibly ascarid eggs enhance the risk of salmonella in outdoor-reared birds, control measures include vaccination and competitive exclusion by promoting gut *Lactobacilli* concentration.
- Organic birds may be vulnerable to *Campylobacter* infection from wild birds and possibly ruminant livestock acting as carriers.
- Breeding for general disease resistance is possible, though complicated. Possibilities in the field of developing the general immune system by bringing young chicks into well-controlled contact with micro-organisms (hygiene theory) should be further researched.
- Examples hygiene theory include administering gut flora to one-day-chicks, keeping young hens in contact with (healthy) older hens, providing compost, access to a free-range area at young age, feeding microbial fermented feeds, etc.

Flock size and its effect on welfare

Investigations into flock size are often confounded by differences in total space available, stocking density and range quality, which are thought to have a larger impact on bird behaviour than flock size. The overriding impact on welfare is the management of all the factors within the system by the stockman, which is made easier by small flock sizes but is not dictated by them. This could support a decision to remain with the current flock size to ensure that producers find it easy to manage their flocks and the welfare outcomes should then be assessed to ensure this. A number of producers would be constrained by this approach however, who would be equally able to manage larger flocks to the same level of welfare. It is worth noting that the largest flock size in this context could not go above the EU regulation limits, which are considered to be small when compared to industry norms (see 'Current industry flock size limits').

Scientific Opinion

Prof Christine Nicol, University of Bristol
Email response:
"Group size- .... My summary is that there is no good welfare reason to limit flock size on the basis of effects of flock size on bird behaviour or other welfare indicators. There may be some advantages (reduced risk of smothering is mentioned but no real evidence) but also disadvantages (often aggression and other problems are higher in small groups). However, there may be other reasons to limit group size - to try to ensure better inspection of individual birds. General conclusion is that other factors (total space available, stocking density, enrichment) have a far bigger impact. Personally, I think group size restrictions may limit good farmers producing more high welfare chicken."

(See Appendix A for full response including evidence)

Dr Claire Weeks, University of Bristol
Email response:
"...In conclusion, recommending flock sizes in the range of 500 to 2,000 would seem reasonable for welfare of hens and broilers in terms of both health and behaviour given the available scientific evidence. There is, however, little evidence that larger flock sizes are

detrimental to welfare, provided that the birds are carefully managed and given access to an enriched environment with multiple opportunities for foraging both indoors and outside plus cover on range. Outcome or bird-based assessments of welfare are important in continuously monitoring the welfare of the flock.

Regarding moving up to 3,000 (hens) or 4,800 (broilers) you could maybe adopt a Swedish-style approach that they have to have above average welfare outcome measures to be allowed that - maybe give limits to mortality, footpad dermatitis and IP scores? If they fail they have to revert to smaller flock sizes..."

(See Appendix B for full literature summary)

Dr Andy Butterworth, University of Bristol
"As far as I am aware there is surprisingly little work on 'colony' or group size in broilers at the 500 to 1000 group size (there is some on 'natural' groupings in wild birds). My feeling would be that the effects of group size in this range is linked with how much time the stockman has to care for the birds - smaller houses may actually take more time to move between and to observe the birds in, but conversely, larger groups may lead to less 'care' per individual animal. The best solution in my opinion would be where higher group sizes are 'permitted' if the farm can demonstrate good welfare outcomes, but if not, then must stay at smaller group size - like the current broiler directive says for stocking density."

Current industry flock size limits

Table 1. Flock size limits for laying hens

	Flock size limit	Standard
Free range		
UK legislation	-	No limit
Free range Lion Code	16,000	Mirrors RSPCA standards
RSPCA FF (>95% of non-cage production)	16,000	Standard E 5.6: For flocks with more than 6,000 birds the following maximum flock and colony (subdivision of a flock) sizes must be adopted: Free-range max flock size 16,000 hens max colony size 4,000 hens
Organic		
EU organic regulation	3000	Article 12 (e) each poultry house shall not contain more than: (ii) 3 000 laying hens,
OFF	3000	standard 10.5.3 v.: as defined in the EU regulation
OF&G	3000	Standard 8.8.37 as defined in the EU regulation
SA	2000	20.0717: The number of birds in each poultry house must not exceed: > 2,000 birds for laying chickens 20.0715: The number of birds in a poultry house *should* not exceed: > 500 for laying and table chickens, ducks, guinea fowl

Table 2. Flock size limits for broilers

	Flock size limit	Standard
Conventional		
UK legislation	-	No limit.
Free range Assured Chicken Production	No limit	No limit stated. Stocking density stated.
RSPCA FF standard	No limit	No limit in standards – guidance suggests a limit of 15,000
Organic		

EU Organic regulation	4800	Article 12 (e) each poultry house shall not contain more than: (i) 4 800 chickens, (f) the total usable area of poultry houses for meat production on any single unit, shall not exceed 1 600 m2;
OF&G	4800	OF &G Standard 8.8.37 vi) Each poultry house must not contain more than 4800 chickens (Table Birds) (*Standard 8.8.46 The flock sizes and stocking densities for table birds introduced on or after 24 August 2010 must not exceed the requirements specified in paragraphs 8.8.37 and 8.8.40.)* *(Standard 8.8.38 For a holding with static houses with 10 table birds per square metre, no more than 16,000 birds can be present at any time. Where the houses are mobile, no more than 25,600 birds can be present at any time (see paragraph 8.8.40).)*
OFF	4800	Standard 10.5.3.v. Each house must not contain more than:4,800 chickens.
SA	1000	Standard 20.0717: The number of birds in each poultry house must not exceed:> 1,000 birds for table chickens, ducks, geese and guinea fowl Standard 20.0715: The number of birds in a poultry house *should* not exceed: > 500 for laying and table chickens, ducks, guinea fowl

Considerations for flock size

Flock size and the interaction with other factors
Flock size and total space provided are often confounded factors in studies. A larger flock will automatically have a larger area provided. Complex relationships exist between spatial allowance per animal, overall enclosure area and group size (Nicol, 2007) and animal behaviour and distribution becomes increasingly unpredictable as group size increases. The quality of the range also appears to interact with flock size to influence the ranging behaviour of the flock.

There is limited evidence that hens prefer smaller group sizes (below 100 birds) in which they can recognise the other hens as individuals (Nicol et al, 1999). It is uncertain whether large group sizes for hens are stressful *per se*. Evidence from the literature suggests that maintaining a certain 'personal space' is a priority for laying hens, although its exact size may alter in different circumstances. Hens may also give greater priority to space than to group size - Lindberg and Nicol (1996) found that hens prefer small groups, but only within large areas. Given a choice between a small (5) and a large (125) group housed at the same stocking density, hens chose the larger group in the larger area. This suggests that preferences for additional space may be stronger than preferences for any particular group size. A similar effect has been recorded in broilers by Mallapur et al., (2009) who concluded that the effect of enclosure size was stronger than the effect of group size. Low space allowance (as a result of small flock size or higher stocking density) has been seen to result in higher feather pecking and aggression (Zimmerman et al., 2006). Spatial factors are relevant for broilers also - group size will affect how broilers space themselves – two forces act i) to reduce competition for food acts to increase distance and ii) to gain protection from the group acts to reduce distance. Several scientific studies suggest reduced stocking densities are beneficial for the welfare of broilers. Overall, the tendency of birds to adopt uneven distributions in large flocks also makes it difficult to prescribe precise space allowances.

A larger flock:

- can provide more space for movement between functional areas meaning there can be less competition for resources and more space to carry out activities.

- tends to have less aggression – it thought that hens can recognise up to approximately 100 other hens and so in group sizes above this there is no individual recognition and a system of social tolerance develops due to lack of social relationships. The lack of social structure can mean that there is lower aggression in larger flocks than in smaller flocks (Hughes et al., 1997) Higher aggression and more feather pecking in a small flock of 2450 compared to a larger flock of 4200 has been reported (cited in Zimmerman et al. (2006)), which it was suggested, could be frustration induced aggression if access to resources were hampered in the smaller flocks. However other studies have found no effects of group size, varying from 250 to 5000 on levels of aggression (Oden et al., 2000).

- can provide greater protection from predators than a smaller group, however this can result in birds that are less motivated to seek cover (Leone et al., 2007).

Things to be aware of:

- careful observation and management is needed as any issue that occurs will affect a greater number of birds in a larger flock

- need to ensure adequate inspection of all birds – time devoted to the attention of individual birds can decrease in larger flocks due to the larger number of birds. Protecting the welfare of victimised birds in particular is important. There are degrees of victimisation and so the design of housing should allow successful avoidance behaviour as this can help combat the physiological stress responses (Freire, 2003).

- ensuring easy access from the house to the range is important as it has been shown to help prevent feather pecking and it encourages diet supplementation from the range. There is some evidence that less birds go out onto the range in larger flock sizes – see Table 3 (Kijlstra et al, 2007), but figures vary between studies even at the same flock size. Range quality has been shown to have a large effect with 75% of hens seen outside in flocks of up to 2000 where cover was provided (Bestman and Wageenar, 2003). Recent work using individually tagged hens in commercial flock sizes is indicating that the majority of birds in a flock do access the range daily but it is likely that in larger flocks and where the range is unattractive they do not remain outside for long on average (Weeks, personal communication).

- There are risks for poor health associated with ranging in hens and these appear to be greater in larger flocks (above 2000) and in static housing (Weeks)

- Larger flocks maybe associated with professional farmers and smaller with smallholders which plays an important role in how long the hens are allowed outside – smallholder flocks have longer access. This effect was reported by Kijlstra et al., (2007) with reference to higher dioxin levels found in smaller flocks (less than 1500 hens) in the Netherlands.
- feather pecking and cannibalism can increase in larger flocks – good management is needed to ensure that they do not become issues. The risk of feather pecking has been found to increase with increasing group size (numerous studies cited in Rodenburg and Koene, 2007). However, other epidemiological studies have found no increased risk of FPC (feather pecking and cannibalism) associated with flock sizes ranging from 250 to 5000 (Oden et al., 2002) or 225 to 9950 (Gunnarsson et al., 1999) in Swedish flocks. The risk for cannibalism does not appear to increase in flock sizes of greater than 225 hens.

- General levels of fear can be greater in a larger flock (Zimmerman et al., 2006)

- The potential for local overcrowding, even smothering, may increase with group size.

- A risk for lower body weight has been identified in larger flocks – good management of body weight is needed (cited in Zimmerman et al., 2006).

Table 3. Analysis of literature data on flock size and use of the outdoor run (Kijlstra et al, 2007).

Flock size	Outside (%)	Reference
50	41.2	Hirt et al., 2000
256	38	Harlander-Matauschek et al., 2006
256	31	Harlander-Matauschek et al., 2006
490	42.1	Bubier and Bradshaw, 1998
500	29.5	Hirt et al., 2000
500	21.5	Zeltner and Hirt, 2003
500	22.5	Zeltner and Hirt, 2003
500	35	Harlander-Matauschek, 2001
500	31.3	Mußlick et al., 2004
1000	22	Harlander-Matauschek, 2001
1432	11.1	Bubier and Bradshaw, 1998
1451	9.2	Bubier and Bradshaw, 1998
2450	5.1	Bubier and Bradshaw, 1998
3000	19.5	Hirt et al., 2000
4500	9.8	Elbe et al., 2005
7000	15.5	Mußlick et al., 2004
16000	4.0	Mußlick et al., 2004
20,000	6.8	Mußlick et al., 2004

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Appendix A

EFSA text (extracted by Nicol, C)

(European Food Safety Authority (2005) The welfare aspects of various systems of keeping laying hens. The EFSA Journal, 197, 1-23 (and Annex))

Feather pecking
Epidemiological studies have found no increased risk of FPC (feather pecking and cannibalism) associated with flock sizes ranging from 250 to 5000 (Oden et al., 2002) or 225 to 9950 (Gunnarsson et al., 1999) in Swedish flocks. Similarly, in beak-trimmed UK flocks there was no increased risk of FPC associated with flock sizes ranging from 800 to 23,000 (Green et al., 2000).

Aggression
In general aggression in large flocks is infrequent, averaging less than one aggressive interaction per bird per hour (Carmichael et al., 1999; Hughes et al., 1997; Nicol et al., 1999), except in the smallest flocks of 72 birds where aggression averaged 1.65 interactions per bird per hour (Nicol et al., 1999). No effects of group size, varying from 250 to 5000 on aggression was reported (Oden et al., 2000).

In non-cage systems, birds housed at 12 birds per m2 have an average spatial provision of 830cm² per bird. An understanding of how birds adapt to the space and social conditions of large flocks is gradually emerging. In larger groups spacing behaviour varies according to activity, time of day and other factors, and space is not evenly used (Carmichael et al., 1999; Appleby, 2004). Social factors such as gregariousness, affiliation, social facilitation, and environmental factors such as the provision of discrete limited resources tend to reduce inter-bird distance and produce clumped distributions (Cooper and Albentosa 2004). Clumped distributions also arise if sub-populations of birds attempt to avoid aggression or threats, or if birds are fearful. Small flocks of unfamiliar birds adopt more uneven distributions than familiar birds (Lindberg and Nicol, 1996). In larger flocks, all birds may be unfamiliar, further contributing to uneven distribution. Channing et al (2001) kept birds in multi-level perchery pens in group sizes ranging from 323 to 912 birds. Each pen was designed to house birds at a constant stocking density of 18 to 18.5 birds/m². However, the birds distributed themselves non-randomly so that within representative observation areas, actual stocking density varied from 9 to 41 birds per m2. Uneven bird distribution gives increased freedom of movement for some birds and decreased freedom for others (Appleby 2004). The potential for local overcrowding, even smothering, may increase with group size. The tendency of birds to adopt uneven distributions in large flocks also makes it difficult to prescribe precise space allowances.

Recent studies have highlighted the fact that sometimes individual birds adopt differential patterns of movement within large houses. Carmichael et al (1999) found that two thirds of marked individuals used 80% of space available to them over the course of a year, and Michel and Huonnic (2003) found that the 93% of sampled birds were observed on 3 or 4 of the four

vertical levels of aviaries. However, other observational and transponder studies have shown that some birds move relatively freely throughout the flock but others restrict themselves to particular areas (Freire et al., 2003; Oden et al., 2000). Birds in flocks of about 500, marked while roosting at ends of pens, were observed in the same area during the day and returned to same sites at night (Oden et al., 2000). This was not the case for birds found roosting in the middle of a pen, which moved randomly during the day. Differentiated movement patterns will increase variability in individual bird welfare in large flocks. Freire et al. (2003) observed sub-populations of birds with relatively poor plumage and low bodyweight, whose movements were restricted to sub-optimal parts of a perchery system. The existence of a small proportion of birds, with very poor welfare, is an issue of great concern.

Early work showed that group size preferences depend on previous experience and familiarity with the choice situation (Dawkins, 1982). Group-size preferences also depend on the amount of space available. Lindberg and Nicol (1996a) found that hens prefer small groups, but only within large areas. Given a choice between a small (5) and a large (125) group housed at the same stocking density, hens chose the larger group in the larger area. This suggests that preferences for additional space may be stronger than preferences for any particular group size.

Within large non-cage flocks it has been suggested that birds might form sub-groups of familiar individuals, hence minimising the risk of meeting strangers (Grigor et al., 1995). Low levels of aggression observed in large flocks (see later) might be a consequence of sub-group formation, such that groups of familiar birds move around together. If so, when birds from different sub-groups meet then aggression would be expected to increase. Hughes et al., (1997) found no evidence of this in mixing experiments, although birds were selected during daytime periods. Oden et al. (2000) studied birds on the basis of night-time resting position. Higher aggression was observed in encounters between birds that roosted far away, than birds that roosted consistently together. This suggests that birds may form night-time sub-groups but move relatively independently throughout the flock during the day.

7.5.2.2 Familiarity Preference

Hens can discriminate between familiar and unfamiliar birds, and can discriminate between particular familiar individuals at close range (Bradshaw, 1991; Dawkins, 1995; 1996; D'Eath and Dawkins 1996). For birds that have formed a social hierarchy, there is strong evidence that they prefer familiar to unfamiliar individuals (Keeling and Duncan 1991; Bradshaw, 1992; Dawkins, 1996) and that unfamiliar birds are aversive (Grigor et al; 1995; Freire et al 1997). Environmental conditions are likely to influence recognition and discrimination abilities of hens.

For birds housed in large flocks where no social hierarchy exists, it is not known whether all conspecifics are perceived as familiar or unfamiliar, or whether any adverse welfare effects arise from this lack of hierarchy formation

7.5.2.3 Social Strategy

Laying hens adopt variable social strategies according to flock size. When group size is relatively small (below approximately 25) birds will rapidly establish a dominance hierarchy. During the establishment of the hierarchy, aggression may be relatively high but overt aggression is rapidly replaced by the use of subtle threat, and relative social stability (Lindberg and Nicol 1996).

In birds that have established a hierarchy, aggression is particularly high when unfamiliar birds are encountered. The maximum number of birds that can be included in a dominance hierarchy is not known, although it may exceed 100 birds (Nicol et al., 1999). However, at this approximate group size aggression may increase, either because birds attempt to form a hierarchy which never quite reaches stability, or because a few birds are not included within the hierarchy and are treated as unfamiliar.

In larger group sizes of many hundreds or thousands, birds might be able to form a hierarchy based not on individual recognition, but on some generic status signal, such as bodyweight or

comb size (Pagel and Dawkins, 1997). Though there is evidence that such signals are used in experimental flocks (Dawkins, 1995; D'eath and Keeling, 2003; Cloutier et al., 1996) the extent to which they play a role in social behaviour in commercial conditions, where single genotype birds of the same age are physically very similar, is unknown (Cooper and Albentosa, 2004).

It seems increasingly likely that birds in large commercial flocks do not develop a hierarchy at all, but instead adopt strategies to avoid negative social interactions.

Appendix B

Summary of literature by Dr Claire Weeks, Bristol University.

There is limited evidence regarding an effect of flock size on welfare issues/indicators in broilers or laying hens. Aggressive behaviour may be seen less often in large flocks (many hundreds or thousands) compared to that reported in small to medium-sized flocks, possibly due to hens not recognising flock mates as familiar or unfamiliar (Hughes et al., 1997). On the other hand, encouraging layers to range is important for reducing the risk of injurious pecking. Some studies have found differences between strains of hen in the use of range. Other factors may affect the use of the range, as this varies between farms and investigations. Lower use of the range tends to be associated with larger flock size, with reported ranges from 4% of hens going outdoors in a flock of 16,000 hens (Mußlick et al, 2004) to over 42% in flocks of 490 hens housed at 5.4 hens/m^2 (Bubier and Bradshaw, 1998). A recent survey of 25 free-range flocks (ranging in size from 3,00-16,000 birds) in the UK found that the estimated use of range in calm, dull weather was 15 to 80% with a median of 30% and fewer birds seen out on range in larger flocks (Whay et al., 2007). Bubier and Bradshaw (1998) also found low use of range for large flocks and higher stocking rates (e.g. mean 5.1 % for flocks of 2,450 housed at 9.1 hens/m^2). A flock size of around 500 birds was recommended by Bestman and Wagenaar (2003) who also found increased range use with smaller flocks, more vegetative or artificial cover, a young age at purchase (ideally farms should rear their own pullets) and an increasing number of cockerels present in the flock. It should be noted that greater use of the range can, occasionally, be associated with unattractive features of the housing, such as the lack of perches and use of plastic perforated flooring (Whay et al, 2007), in which case the welfare of the hens is compromised.

It is also important to note that these older studies of range use are 'snapshot' views. Recent work using RFID tags shows that the majority of birds in a flock do access the range daily (80% in the study by Richards et al, 2011 in flock sizes of 1,500 hens). It is likely, however, that in larger flocks and where the range is unattractive they do not remain outside for long on average. Bright et al (2011) found that plumage damage reduced with increasing tree cover on range and proposed a minimum of 5% of the range should incorporate trees and that some of these should be placed close to the house. Poor weather also decreases time on the range (Richards et al, 2011), and Bright et al (2011) suggested that flocks placed in the autumn or winter may have ranged less, leading to increased plumage damage. The provision of verandas is likely to be of great benefit, particularly for newly placed flocks and in inclement weather. The risks for poor health associated with ranging appear to be greater for larger flocks and in static housing.

Evidence from the literature suggests that maintaining a certain 'personal space' is a priority for laying hens, although its exact size may alter in different circumstances. Hens may also give greater priority to space than to group size, and there is limited evidence that they prefer

smaller group sizes (below 100 birds) in which they can recognise the other hens as individuals. It is uncertain whether large group sizes are stressful *per se.*

While there are several scientific papers suggesting reduced stocking densities are beneficial for the welfare of broilers I can find only one looking specifically at flock size and this was in very small experimental flocks of 50 to 200 birds. Although it suggested reduced aggression and improved ranging in the small group size it is not applicable to commercial flocks.

In conclusion, recommending flock sizes in the range of 500 to 2,000 would seem reasonable for welfare of hens and broilers in terms of both health and behaviour given the available scientific evidence. There is, however, little evidence that larger flock sizes are detrimental to welfare, provided that the birds are carefully managed and given access to an enriched environment with multiple opportunities for foraging both indoors and outside plus cover on range. Outcome or bird-based assessments of welfare are important in continuously monitoring the welfare of the flock.

Appendix C

EU broiler directive (Council Directive 2007/43/EC)

ANNEX II (ctd)
REQUIREMENTS FOR THE USE OF HIGHER STOCKING DENSITIES
Notification and documentation

2. The owner or keeper shall maintain and have available in the house compiled documentation describing in detail the production systems. In particular it shall include information on technical details of the house and its equipment such as:
(a) a plan of the house including the dimensions of the surfaces occupied by the chickens;
(b) ventilation and, if relevant, cooling and heating system, including their location, a ventilation plan, detailing target air quality parameters, such as airflow, air speed and temperature;
(c) feeding and watering systems and their location;
(d) alarm systems and backup systems in the event of a failure of any automated or mechanical equipment essential for the health and well-being of the animals;
(e) floor type and litter normally used.
The documentation shall be made available to the competent authority on request and shall be kept updated. In particular, technical inspections of the ventilation and alarm system shall be recorded.
The owner or keeper shall communicate to the competent authority any changes to the described house, equipment or procedures which are likely to influence the welfare of the birds without undue delay.
Requirements for the holdings — control of environment parameters
3. The owner or keeper shall ensure that each house of a holding is equipped with ventilation and, if necessary, heating and cooling systems designed, constructed and operated in such a way that:
(a) the concentration of ammonia (NH3) does not exceed 20 ppm and the concentration of carbon dioxide (CO2) does not exceed 3 000 ppm measured at the level of the chickens' heads;
(b) the inside temperature, when the outside temperature measured in the shade exceeds 30 °C, does not exceed this outside temperature by more than 3 °C;
(c) the average relative humidity measured inside the house during 48 hours does not exceed 70 % when the outside temperature is below 10 °C.

ANNEX III
MONITORING AND FOLLOW-UP AT THE SLAUGHTERHOUSE
(as referred to in Article 3(1))
1. *Mortality*

1.1. In the case of stocking densities higher than 33 kg/m2, the documentation accompanying the flock shall include the daily mortality rate and the cumulative daily mortality rate calculated by the owner or keeper and the hybrid or breed of the chickens.
1.2. Under the supervision of the official veterinarian these data as well as the number of broilers dead on arrival shall be recorded, indicating the holding and the house of the holding. The plausibility of the data and of the cumulative daily mortality rate shall be checked taking into account the number of broilers slaughtered and the number of broilers dead on arrival at the slaughterhouse.
2. *Post-mortem inspection*
In the context of the controls performed under the Regulation (EC) No 854/2004, the official veterinarian shall evaluate the results of the post-mortem inspection to identify other possible indications of poor welfare conditions such as abnormal levels of contact dermatitis, parasitism and systemic illness in the holding or the unit of the house of
the holding of origin.
3. *Communication of results*
If the mortality rate as referred to in paragraph 1 or the results of the post-mortem inspection as referred to in
paragraph 2 are consistent with poor animal welfare conditions, the official veterinarian shall communicate the data to
the owner or keeper of the animals and to the competent authority.

ANNEX V
CRITERIA FOR THE USE OF INCREASED STOCKING DENSITY
(as referred to in Article 3(5))
1. *Criteria*
(a) the monitoring of the holding carried out by the competent authority within the last two years did not reveal any
deficiencies with respect to the requirements of this Directive, and
(b) the monitoring by the owner or keeper of the holding is carried out using the guides to good management practice
referred to in Article 8, and
(c) in at least seven consecutive, subsequently checked flocks from a house the cumulative daily mortality rate was
below 1 % + 0,06 % multiplied by the slaughter age of the flock in days.
If no monitoring of the holding was carried out by the competent authority within the last two years, at least one
monitoring exercise has to be carried out to check whether requirement (a) is fulfilled.
2. *Exceptional circumstances*
By the way of derogation from 1(c), the competent authority may decide to increase the stocking density when the
owner or keeper has provided sufficient explanation for the exceptional nature of a higher daily cumulative mortality
rate or has shown that the causes lie beyond his sphere of control.