Welfare and productivity of laying hens in commercial organic egg production systems in Denmark

L. Hegelund[1,*], J.T. Sørensen[1] and J.E. Hermansen[2]

[1] Department of Animal Health, Welfare and Nutrition, Danish Institute of Agricultural Sciences (DIAS), Research Centre Foulum, P.O. Box 50, DK-8830 Tjele, Denmark

[2] Department of Agroecology, Danish Institute of Agricultural Sciences (DIAS), Research Centre Foulum, Tjele, Denmark

[*] Corresponding author (e-mail: lene.hegelund@agrsci.dk)

Received 9 August 2005; accepted 21 August 2006

Abstract

Plumage condition, use of outdoor run, mortality and productivity were recorded in 18 Danish commercial organic egg-producing flocks consisting of 1200–5000 hens each. Between 7 and 38% of the hens in a flock used the outdoor run, with a mean of 18%. In most flocks the majority of the hens outside stayed close to the hen house, but some farmers succeeded in attracting the hens away from the house, which reduced the percentage of hens staying close to the house to 15%. At the age of 56 weeks, six flocks had little or no plumage damage, whereas four flocks showed severe feather pecking, but here feather pecking was already evident at an age of 28 weeks. Plumage condition was not significantly correlated with use of the outdoor run. The range in mortality rate amongst flocks was 9–62%, with an average of 22%. The high mortality was partly due to outbreaks of Pasteurella, mortality reaching over 50% in two of the four afflicted flocks. In some flocks also predatory attacks and piling (causing suffocation of the lowest birds) caused mortality. Average egg production was better than reported for Danish organic and free-range non-organic farms, but feed consumption and feed conversion rate were slightly higher. The results of this study do not provide a definite answer to the question whether or not hens should be kept outside.

Additional keywords: welfare indicators, free range

Introduction

In Denmark, 23% of all eggs delivered to the egg packing stations come from hens having access to an outdoor run, including free-range (9.2%) and organic layers. Characteristic of these two production systems is that flocks are loose-housed and have daily access to an outdoor run with a minimum area per hen of 4 m^2.

An outdoor run provides the hens with a more natural and stimulating environment and a reduced animal density in the hen house during daytime. So an outdoor run can contribute to the welfare of the flock. However, often only a fraction of the hens uses the outdoor run, and the majority of the outdoor hens stay close to the house (Hughes & Dun, 1982; Keeling *et al.*, 1988; Zeltner & Hirt, 2003). This reduces the potential benefits of the outdoor run and puts an uneven pressure on the run's area, increasing the risk of nutrient leaching, parasitic contamination and degradation of the vegetation in the vicinity of the house (Menzi *et al.*, 1997; Permin *et al.*, 1999; Hermansen *et al.*, 2005). But outdoor runs also have disadvantages. The surveillance of loose-housed flocks with access to an outdoor run is more difficult and the control of the animals' environment is reduced. This can result in a higher mortality rate due to diseases, inappropriate behavioural patterns (vent pecking, cannibalism, clumping/piling) or predatory attacks.

Indicators of animal welfare, health and productivity, including housing conditions and use of the outdoor run were recorded in a study on seven commercial Danish farms with a total of 18 organic egg-producing flocks. In this paper, results are presented and relations between welfare and husbandry conditions are analysed.

Materials and methods

The study was carried out in the period 2000–2003 and involved 18 flocks. Flock size ranged from 1200 to 5000 hens and included five different breeds: Isa Brown (6 flocks), Isa Babcock (4 flocks), Hyline Brown (5 flocks), Lohmann Brown (2 flocks) and Hellevad White (1 flock). Most flocks had been purchased at the age of 16 to 17 weeks and were slaughtered at the age of 53 to 92 weeks.

Figures on egg production and feed consumption were calculated using invoices and information from feed mills and egg packing stations. Numerical mortality was recorded by producers' information and were validated through information on numbers of hens purchased and sold. Causes of death were recorded by the producers (categories: 'clumping', 'predators', 'other causes') and further analysis on a stratified sample of dead hens in the 'other' category was carried out through internal autopsies by a veterinarian laboratory. Autopsies also included presence of intestinal nematodes.

Ten flocks (flock numbers 4 and 10–18) were visited eight times (when hens were 20, 24, 28, 36, 44, 52, 60 and 68 weeks old) for recording of plumage condition and the use of the outdoor run. Eight flocks (flock numbers 1–3 and 5–9) were visited four times (at approximately 28, 44, 56 and 68 weeks of age) for plumage condition score and every four weeks for recording the use of the outdoor run (total 7–15 times per flock depending on the length of the production period). Due to visit restrictions caused by an outbreak of Newcastle disease in Denmark in the summer of 2002, two of the eighteen flocks were visited less frequently.

Technicians of the Danish Institute of Agricultural Science (DIAS) recorded the use of the outdoor run twice per visit together with wind speed, precipitation and temperature. The first recording was performed in the morning, 15 minutes after opening the pop holes, and the second one between 3 and 5 p.m. The outdoor runs

were divided into at least four sections: 0–5, 5–35, 35–100 and > 100 m as measured from the hen house. The numbers of hens were estimated per section, using the 'block method' (Harrison *et al.*, 2002). Use of the outdoor run is affected amongst other things by weather (precipitation, wind speed and temperature) and season. A weather/season-corrected data set of the use of the outdoor run was created for analyses of relations with flock size and plumage condition, using the method described by Hegelund *et al.* (2005).

Plumage condition was rated by technicians of DIAS on a scale of 5 to 20, with a score of 5 for heavily damaged feathers on back, tail, breast, wings and neck, and a score of 20 for intact plumage on all these body parts (Tauson *et al.*, 1984). The 'mean plumage condition' per flock was calculated as the mean rating of 50 hens. The hens were chosen at random, catching them in the morning from different spots in the houses before turning on the lights. The plumage condition of hens deteriorates with age as a result of several causes, including feather pecking. A plumage score of 17.5 at the age of 56 weeks was considered as relatively good.

Results

Productivity

Data on egg production and feed consumption for each flock are presented in Table 1. The number of eggs laid during the production period varied amongst flocks and ranged from 195 to 331 per hen, with an average for all flocks of 257. In terms of weight, egg production varied amongst flocks from 12.5 to 23.7 kg per hen, with a mean of 16.3 kg. Also the quantity of feed consumed per hen varied amongst flocks and ranged from 123 to 156 g per day, with a mean of 137 g. The feed conversion rate – the amount of feed required to produce one kg eggs – ranged from 2.58 to 3.50 kg, with a mean of 2.87 kg.

Mortality

Total mortality amongst flocks varied from 8.6 to 62.3%, with a mean of 22.5% (Table 2). The high mortality rates were partly due to outbreaks of Pasteurella, since mortality reached over 50% in two of the four afflicted flocks. Piling, which causes suffocation of the lowest birds (clumping), was frequently observed and accounted for 0 to 7.9% mortality, with an average of 3.8%. Based on the data recorded by the producers, predatory attacks ranged from 0 to 14.2%. Other causes of death accounted for 8.0% of the losses and on average 3.4% of the hens were missing, with a relatively large range (0–11.9%). No clear explanation can be given for the high number of missing hens, but it is assumed that predators took most of them. Under this assumption the mean predatory loss was estimated at 6.4% (sum of 'predators' and 'missing'), with five flocks losing more than 10% (flocks 12–17), whereas some flocks had experienced no losses at all.

Regular autopsies of 16 flocks showed that some degree of vent pecking – often

Table 1. Egg production and feed consumption per flock or combination of flocks.

Flock No.	Egg production		Feed consumption	
	(number per hen)	(kg per hen)	(g per hen per day)	(kg feed per kg eggs) [1]
2	331	20.9	127	2.60
3	362	23.7	129	2.58
4	311	20.2	129	2.80
5	279	17.3	133	2.79
6	234	14.4	156	2.77
7	247	15.2	149	2.90
8	284	18.8	152	2.80
9	264	17.4	147	2.90
10	216	12.9	129	3.00
11	212	12.8	123	2.90
12–14	214	13.6	140	3.50
15+16	224	14.0	141	3.30
17+18	195	12.5	129	2.90
Mean	257	16.3	137	2.87
Mean organic [2]	234	14.8	131	2.79
Mean free-range [2]	261	16.4	125	2.48

[1] Feed conversion rate (FCR).

[2] Average production results for organic and free-range brown layers (21–68 weeks old) in the period 1999–2003 (Anon., 2004).

resulting in an *Escherichia coli* infection – occurred in most (14) flocks. Intestinal nematodes (*Ascaridia galli*) were found in 10 of the 16 flocks, and in 7 of these flocks at least one animal was infested with over 20 nematodes.

Use of the outdoor run

The use of the outdoor run varied strongly between flocks. The flock that used the outdoor run most respectively least had on average 38% and 8% of the hens outside, whereas the mean for all flocks was 18%. The standard deviation within flocks ranged from 5.5 to 20.6, showing large variations with time.

The distribution of the hens over the outdoor run is shown in Figure 1. In most cases over 40% of the hens stayed very close to the hen house (0–5 m; flock numbers 1, 2, 4, 5, 12, 14, 17, 18). In four cases (flock numbers 10, 11, 13 and 16) the farmers succeeded in attracting the hens away from the direct vicinity of hen house (less than 40% of the hens in the zone 0–5 m); but even then less than 20% of the hens was further away than 35 m from the house. Flock 15 showed a more or less equal distribution of hens over the four zones in the outdoor run.

Table 2. Cause of death (%) and total mortality rate (%) per flock as recorded by producers. In flocks 5–9 cause of death was not recorded by the producers. Total mortality may differ 0.1% from the sum of individual causes due to numerical rounding off.

Flock No.	Cause of death				Total mortality
	Clumping	Predators	Other	Missing [1]	
	(%)				
1	0.5	1.6	7.6	1.8	11.4
2	0	0.6	13.9	4.4	18.8
3	1.8	5.6	8.2	0	15.7
4	2.7	0	4.0	1.9	8.6
5	-	-	-	4.6	16.9
6	-	-	-	1.0	62.3 [2]
7	-	-	-	1.1	54.3 [2]
8	-	-	-	0	13.4
9	-	-	-	0	11.1
10	7.9	0	7.4	0	15.3
11	4.9	0	7.5	0	12.4
12	5.3	2.0	6.0	10.8	24.1 [2]
13	5.2	0.7	8.1	10.1	24.1 [2]
14	5.6	1.0	5.6	11.9	24.1
15	0.2	13.9	14.0	0	28.1
16	2.3	14.2	14.2	0	30.8
17	6.2	0	2.1	9.3	17.5
18	7.1	0	5.0	3.6	15.7
Mean	-	-	-	3.4	22.5

[1] Missing = percentage death not accounted for at final slaughter; probable causes: sold, or death or absence not registered.

[2] Outbreak of Pasteurella.

There was no clear correlation (Spearman; R = –0.13, $P = 0.59$) between initial flock size and mean percentage of the flock observed outside.

Plumage condition

Figure 2 shows the course of the mean plumage condition with time of all 18 flocks. At the age of 56 weeks, the plumage condition of six flocks was rated higher than 17.5, indicating little or no damage, whereas four flocks were rated lower than 13.5, an indication of severe feather pecking. The flocks in Figure 2 were divided into two groups based on their plumage condition at 28 weeks of age (higher or lower than 19.5). The

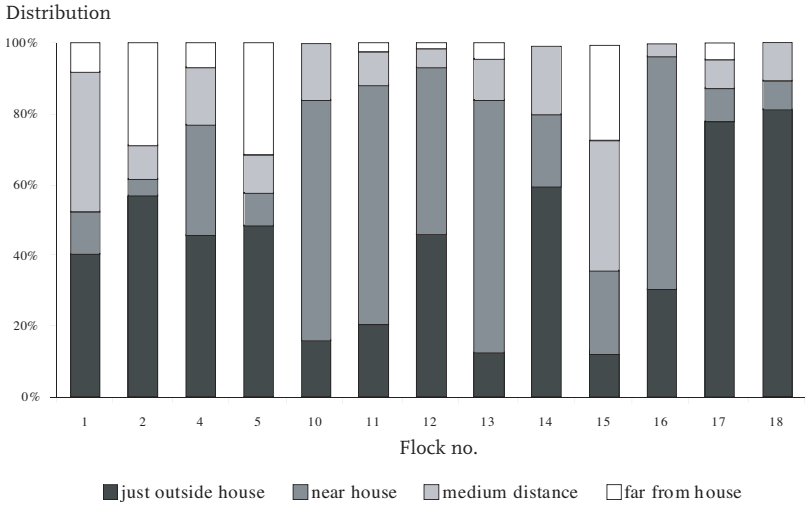

Figure 1. Distribution of the hens in the outdoor run for 13 flocks. Overall percentage of the hens observed in the following sections: just outside the house (approx. 0–5 m), near the house (approx. 5–35 m), medium distance (approx. 35–100 m) and far from house (approx. > 100 m). The remaining five flocks were not included because sections were not in agreement with these four categories.

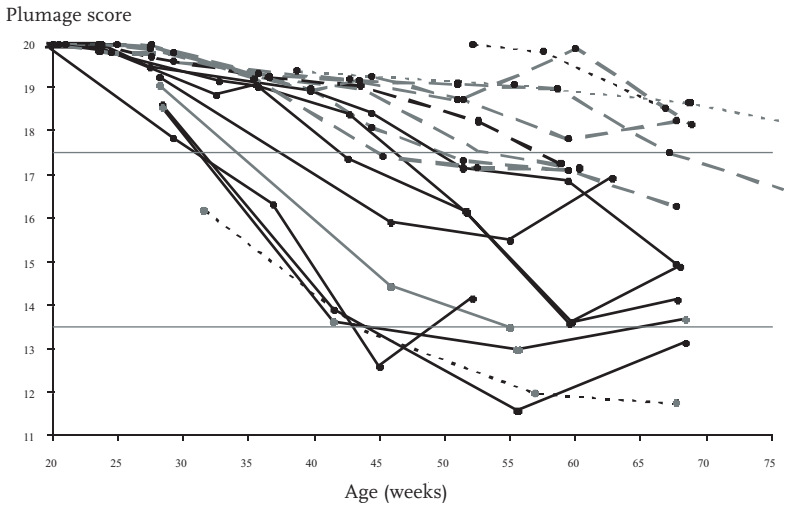

Figure 2. Course of the mean plumage condition of the 18 flocks studied – measurements (dots) and trend lines. Flocks scoring higher than 19.5 points at the age of 28 weeks are indicated by dashed lines, and flocks scoring lower than 19.5 points by solid lines. Dotted lines represent flocks scored after 28 weeks of age only. If measurements at week 28 were not available, the missing values were estimated by interpolation. Levels to distinguish between categories of plumage condition are indicated by horizontal lines at scores 17.5 and 13.5.

disposition to feather pecking was already evident at an early age. At the end of the production period all flocks but one that had been rated higher than 19.5, had a better plumage condition than the flocks in the other group.

There was no clear correlation (Spearman; R = 0.26, $P = 0.31$) between plumage condition at 56 weeks of age and the use of the outdoor run.

Discussion

The egg production results in our study were on average better than the average results for organic and free-range non-organic flocks during the period 1999–2003 as reported by the Danish Poultry Council (Anon., 2004; see Table 1), and the average feed consumption and feed conversion rate were slightly higher. These observations might be biased by the fact that feed consumption (and egg production) covered the entire period, i.e., from placement of the flocks, whereas productivity figures are often calculated from the moment flocks are in full lay.

In our study the mortality rate was high. There were problems with inappropriate behavioural patterns of the hens (vent pecking, feather pecking and clumping). In some flocks also diseases and predatory attacks caused serious problems. The exact causes of the problems, which were related to (a combination of) design of the outdoor run, management of the loose-housed flocks, genetics and rearing of the hens, did not become evident from this study.

There were clear differences amongst flocks in the percentage of hens outside and the distribution of the flock over the outdoor run. The large variation amongst flocks of the same size – also if corrected for weather/season – indicated that other factors significantly affect the hens' use of the run. Management and design of the outdoor run differed much amongst flocks, and other studies have shown significant effects of the presence and type of cover and vegetation (Grigor & Hughes, 1993; Zeltner & Hirt, 2003), farmers' experience, hens' age at purchase and presence of cockerels (Bestman & Wagenaar, 2003).

At the end of the production period the 18 flocks differed markedly in degree of feather pecking. Their plumage condition ranged from almost perfect to severely damaged. The results showed that flocks ending up with substantial feather damage can already be identified early in the production, making plumage condition at the age of 28 weeks a possible early indicator of the future welfare status of the flock. This also indicated that an early effort is needed to prevent and reduce feather pecking, which could imply increased focus on the farmers' management during rearing and the first stage of the production period.

Although not evident from our study, studies of Nicol *et al.* (1999) and Bestman & Wagenaar (2003) have shown positive correlations between plumage condition and use of the outdoor run. But the causal relationship was not clear. It could be the lack of the plumage's insulating effect that makes the hens refrain from exposing themselves to the weather conditions of the outdoor run. On the other hand, it could also be that a limited use of the outdoor run and the consequent less stimulating environment would result in individuals that are more susceptible to feather pecking. Also, a lower

use of the outdoor run will lead to a higher density in the hen house, which is another parameter that has been associated with feather pecking (Nicol *et al.*, 1999). Finally, both feather pecking and use of the outdoor run have been associated with fear (Kjaer, 1999, Grigor *et al.*, 1995), and could therefore be related through this third parameter.

Our results do not provide a final conclusion as to the question of whether or not hens should be kept outside. When discussing the aspects of health and welfare it is necessary also to define and compare elements of positive welfare, such as explorative behaviour and a stimulus-rich environment (Hughes, 1992; Sandøe & Simonsen, 1992), and compare both the advantages and disadvantages of the free-range systems with the advantages and disadvantages of other production systems. In fact, conclusions cannot be based solely on average data of mortality, plumage condition and productivity. Other issues, such as ethics and environmental considerations should also be taken into consideration. Moreover, we observed that some producers were able to keep loose-housed hens with access to an outdoor run and have little mortality, a good plumage condition and an acceptable productivity, whereas others had welfare problems and/or low productivity. So it should be investigated what management tools are required to reduce the risks of these systems.

Acknowledgements

This study was financed by the Danish research school 'SOAR' (Research School for Organic Agriculture and Food Systems) and the DIAS research projects 'Demonstration and Implementation of New Organic Production Systems' and 'Organic Egg Production, Development of New Systems and Control Methods for Improving Animal Welfare and Food Security'.

References

Anonymous, 2004. Annual Report. Danish Poultry Council. Copenhagen, 131 pp. (in Danish)

Bestman, M.W.P & J.P. Wagenaar, 2003. Farm level factors associated with feather pecking in organic laying hens. *Livestock Production Science* 80: 133–140.

Grigor, P.N. & B.O. Hughes, 1993. Does cover affect dispersal and vigilance in free-range domestic fowls? In: C.J. Savory & B.O. Hughes (Eds), Proceedings of the 4th European Symposium on Poultry Welfare, 18–21 September 1993, Edinburgh. Universities Federation for Animal Welfare (UFAW), Herts, pp. 246–247.

Grigor, P.N., B.O. Hughes & M.C. Appelby, 1995. Effects of regular handling and exposure to an outside area on subsequent fearfulness and dispersal in domestic hens. *Applied Animal Behaviour Science* 44: 47–55.

Harrison, J., D. Allan & D.Harebottle, 2002. Coordinated Waterbird Counts (CWAC). Information Sheet No 4. Basic Counting Techniques. Avian Demography Unit, University of Cape Town, Cape Town, 3 pp.

Hegelund, L., J.T. Sørensen, J.B. Kjær & I.S. Kristensen, 2005. Use of the range area in organic egg

production systems: effect of climatic factors, flock size, age and artificial cover. *British Poultry Science* 46: 1–8.

Hermansen, J.E., K. Horsted, L. Hegelund, C. Frantzen & N.F. Johansen, 2005. Improved range areas in organic egg production. DIAS Report No 67, 71 pp. (in Danish)

Hughes, B.O., 1992. Welfare from the hen's viewpoint – can we ask her what she needs? In: Proceedings of the 19th World's Poultry Congress, 20–24 September 1992, Amsterdam. Vol. 2. World's Poultry Science Association, Wageningen, pp. 311–314.

Hughes, B.O. & P. Dun, 1982. A Comparison of two Laying Strains: Housed Intensively in Cages and Outside on Free Range. Research and Development Publication No 16. The West of Scotland Agricultural College, Glasgow, 9 pp.

Keeling, L.J., B.O. Hughes & P. Dun, 1988. Performance of free-range laying hens in a polythene house and their behaviour on range. *Farm Building Progress* 94: 21–28.

Kjaer, J.B., 1999. Feather pecking in laying hens: Genetic and environmental factors. PhD thesis Department of Animal Health and Welfare. Danish Institute of Agricultural Sciences, Research Centre Foulum, Tjele, 148 pp.

Menzi, H., H. Shariatmadari, D. Meierhans & H. Wiedmer, 1997. Nähr- und Schadstoffbelastnung von Geflügelausläufen. *Agrarforschung* 4: 361–364.

Nicol, C.J., N.G. Gregory, T.G., Knowles, I.D. Parkman & L.J. Wilking, 1999. Differential effects of increased stocking density, mediated by increased flock size on feather pecking and aggression in laying hens. *Applied Animal Behaviour Science* 65: 137–152.

Permin, A., M. Bisgaard, F. Frandsen, M. Pearman, J. Kold & P. Nansen, 1999. Prevalence of gastroin testinal helminths in different poultry production systems. *British Poultry Science* 40: 439–443.

Sandøe, P. & H.B. Simonsen, 1992. Assessing animal welfare: where does science end and philosophy begin? *Animal Welfare* 1: 257–267.

Tauson, R., T. Ambrosen & K. Elwinger, 1984. Evaluation of procedures for scoring the integument of laying hens - independent scoring of plumage condition. *Acta Agriculturæ Scandinavica* 34: 400–408.

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