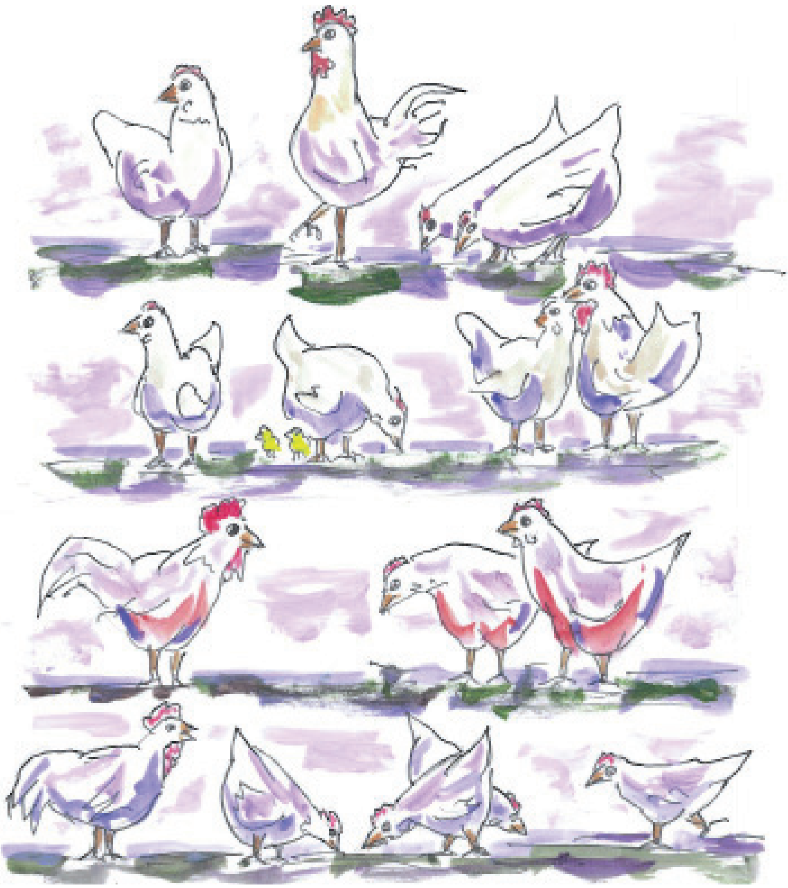
Management Systems for Organic Egg Production - Aiming to Improve Animal Health and Welfare

Lene Hegelund



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Revised reprint of PhD thesis by
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Preface and acknowledgements

The Ph.D. study was conducted at the Danish Institute of Agricultural Science (DIAS), Department of Animal Health, Welfare and Nutrition, and at the Royal Veterinary and Agricultural University, Department of Large Animal Sciences, Production and Health. The Ph.D. study was financed partly by DIAS and partly by the Research School for Organic Agriculture and Food Systems (SOAR).

I would like to thank all the people who made it possible to carry out this Ph.D. study:
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Finally, I would like to thank my family for their support, my father for his beautiful drawings, my husband Mogens, for always being there, and my two kids Sofie and Sebastian for quality assurance and keeping things in their right perspectives.

Lene Hegelund

Foulum, December 2006

Contents

Summary

Animal health and welfare is an important part of the organic husbandry, both in terms of the organic principles and because of consumer interest. But problems in the organic egg production resulting in diseases, feather pecking and cannibalism, have led to the need of management tools in order to secure animal health and welfare.

The aim of this project is to develop management tools for the organic egg production, aimed to secure animal health and welfare in the flocks.

In the first part of the project a welfare assessment system for organic egg production was developed and tested on five farms, having a total of ten flocks. The ten flocks were monitored regularly for a number of production and welfare parameters in order to evaluate the practical applicability of the welfare assessment system. A welfare assessment report was created and presented for each producer, and the welfare assessment system was evaluated with respect to its function as a decision support tool. In addition two welfare indicators were studied separately to evaluate variability and interpretation. Adjustments for the welfare assessment system were suggested, in order to improve collected data, presentation and the practical applicability of the system.

In the second part of the project the first part of a HACCP system was developed, using an expert panel analysis. Eighteen experts received a series of questionnaires, where the construction of each questionnaire was based upon the answers of the former. By quantifying the experts' opinions, ten health and welfare problems were selected, and associated risk factors and control points identified. A generic HACCP system was described together with the possibilities of evaluating the system and possibilities of a practical application.

The two management tools have very different approaches to improving animal health and welfare, and subsequently different methods, cost and advantages. This makes them relevant for different purposes and by different producers and interested parties.

The thesis includes four papers describing the development of the welfare assessment system (paper I), and evaluation of two welfare indicators included in the welfare indicator protocol (paper II and II). Finally the development of the HACCP-like system is described in paper IV:

paper I: Hegelund, L., Sørensen, J.T. & Johansen, N.F. (2003) Developing a welfare assessment system for use in commercial organic egg production. Animal Welfare 12(4), 649-654.

paper II: Hegelund, L. & Sørensen, J.T. (2007) Measuring fearfulness of hens in commercial organic egg production. Animal Welfare 16, 167-171.

paper III: Hegelund, L., Sørensen, J.T. Hegelund, L., Sørensen, J.T., Kjær, J.B. and Kristensen, I.S. (2005) Use of the range area in commercial egg production systems: Effect of climatic factors, flock size, age and artificial cover. British Poultry Science 46(1): 1-8.

paper IV: Hegelund, L. & Sørensen, J.T. (in press) Developing a HACCP-like system for improving animal health and welfare in organic egg production - based on an expert panel analysis. Animal.

Sammendrag

Husdyrsundhed og velfærd er en vigtig del af økologiske jordbrug, både på baggrund af de økologiske principper, men også på grund af forbrugernes interesse i emnet. Problemer i den økologiske ægproduktion med sygdom, fjerpilning og kannibalisme har ført til et behov for styringsredskaber til sikring af dyrenes sundhed og velfærd.

Målet med dette projekt var at udvikle styringsredskaber til økologiske ægproduktion, med henblik på at sikre dyrenes sundhed og velfærd.

I første halvdel af afhandlingen udvikles et velfærdsvurderingssystem til brug i kommerciel økologisk æg produktion. Systemet testes på ti flokke fra fem gårde for at evaluere den praktiske anvendelighed af systemet. Der foretages jævnlige registreringer af velfærdsindikatorer i de ti flokke. Efterfølgende udarbejdes en velfærdsvurderingsrapport, som præsenteres for producenterne med det formål at evaluere rapportens brugbarhed som et redskab til beslutningsstøtte. Tillige analyseres to velfærdsindikatorer i andre besætninger for at evaluere deres stabilitet og tolkning. Velfærdsvurderingssystemet justeres efter afprøvningerne og analyserne for at forbedre datakvaliteten, præsentationen samt den praktiske anvendelighed af systemet.

I anden halvdel af afhandlingen udvikles første del af et HACCP system vha. en ekspertpanel-analyse. Atten eksperter deltager i ekspertpanelet, hvor de modtager i alt fire spørgeskemaer. Andet, tredje og fjerde spørgeskema er alle baseret på besvarelserne fra det tidligere spørgeskema. Ved at kvantificere eksperternes besvarelser udvælges ti sundheds- og velfærdsproblemer og deres associerede risikofaktorer og endelig identificeres mulige kontrolpunkter for disse risikofaktorer. Et generisk HACCP system beskrives og muligheder for at videreudvikle og evaluere systemet diskuteres. Slutteligt diskuteres mulighederne for praktisk anvendelse af HACCP-systemet.

De to management-redskaber er i udgangspunktet meget forskellige, trods det at de begge er målrettet mod at forbedre husdyrsundhed og velfærd i den økologiske ægproduktion. De forskellige metoder der benyttes, omkostninger ved systemerne og fordele ved redskaberne medfører, at de er relevante i forskellige sammenhænge.

Afhandlingen inkluderer fire artikler, der beskriver udviklingen af velfærdsvurderingssystemet (artikel I), evalueringen af to velfærdsindikatorer, inkluderet i velfærdsvurderingssystemet (artikel II og III), samt udviklingen af HACCP-systemet (artikel IV).

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1 Introduction

1.1 Background

In Denmark there is a considerable demand for organic foods, and consumer interests have been related to food safety issues, environmental concern and animal welfare (Hermansen, 2003). Organic sales increased with more than 12% in 2005 with milk, cheese and egg being major contributors to the total sale (Danmarks statistik, 2006). The organic egg production holds a market share of 14% of the total egg production in Denmark (Madsen, 2006). This is exceptionally high compared to other European countries (Windhorst, 2005), and it makes organic egg production an important actor in Danish agriculture.

The agricultural development has since 1960 led to increasingly bigger farms and specialised production, and this development is now also seen within organic agriculture (Anon., 2006). Consequently flocks are getting bigger and time per animal is reduced. Besides the increase in farm size the production has been highly specialised. Meat and egg production are completely separated, and the breeds used in commercial egg production are produced by a few trans-national breeding companies (Sørensen, 2001). The breeding companies are providing hatcheries with a parent stock, and they deliver day-old chickens for rearers. The rearers house the chickens until they are about 16-18 weeks of age, then they are transported to the egg production facilities. In organic egg production hens are housed in free ranging flocks of 3000 hens with access to perches, littered floor, sand bathing areas, and nests.

However, European reports show that organic egg production struggles with serious problems, e.g. feather pecking, infectious diseases and parasites reducing animal welfare (Bestman and Maurer, 2006). This probably relates to a combination of the specialised production and the large loose housed flocks. Producers have limited options for choosing breeds well adapted to the production system as the selection for a long time have been based on caged hens (Sørensen, 2001) and they have little control over the rearing period. The large loose housed flocks are difficult to monitor, infectious diseases can spread rapidly due to the many possibilities for animal interactions, and finally the access to an outdoor area limits the possibilities for bio security. In addition the organic regulation limits the use of disinfectants, veterinarian remedies, and pesticides. As a result the organic egg production in Denmark depends on large flocks of high yielding animals which are presently not properly/optimally selected to the systems. This means that the hens' coping capabilities are basically challenged in all commercial organic flocks, so even minor disturbances can tip the balance of the hens resulting in serious behavioural problems. Consequently, it is essential to optimize farm management in order to reduce any such disturbances.

Often a distinction is made between three levels of management: operational management, tactic management and strategic management, related to different time horizons and impact of the decisions (e.g. Huirne and Dijkhuizen, 1997). And studies of risk factors for the production problems can relate to all three categories. Improvements of operational management in terms of daily routines with fewer disturbances have been shown to reduce feather pecking (e.g. Green et al., 2000). Tactic management in terms of vaccinations schedules and pasture rotation can reduce infectious diseases and intestinal parasites. And finally improvement of the range area or changing flock sizes, which are related to reduced feather pecking (e.g. Bestman and Wagenaar, 2003) are parts of the strategic management.

In the present study two different management tools, with the purpose of improving animal health and welfare, are developed. (1) A welfare assessment system using reports of risk factors and status of animal health and welfare in a benchmarking system. The welfare assessment system is designed as a decision support tool for the farmers, aimed at tactic and strategic management. (2) A HACCP-like system using monitoring and control of risk factors in a quality control system. The HACCP system provides a set of guidelines for better control with operational management.

1.2 The aim of the PhD project

The overall aim of the PhD project was to develop two different management systems for use in organic egg production systems in order to improve animal health and welfare.

The individual aims were:
- Development and presentation of a welfare assessment system for organic egg production (paper I)
- Evaluating measures/indicators of welfare for use in the welfare assessment system (paper II & III)
- Developing a generic HACCP-like system adaptable for organic egg production (paper IV)

2 The Welfare assessment system

2.1 Introduction

Systems applied to assess animal welfare at herd or flock level has gained increasing interest during the last 20 years, and a vide range of different systems have been developed. However the methods used to evaluate welfare differ and this can be related to their different goals and their basic welfare definitions (Johnsen et al., 2001; Main et al., 2003).

Welfare assessments can use information from different sources: the environmental parameters (system, management) influencing the animals, and the animal based parameters (animal health, animal behaviour) expressing the animals' response to the environment. And different welfare assessment systems rely on different weighing of these information sources (Johnsen et al., 2001). If the goal of a welfare assessment is to investigating the impact of the housing systems on animal welfare (e.g. conventional vs. organic), then environmental parameters are often dominating. The certification systems 'Tiergerechtheitsindex' (TGI) 35L aiming to secure minimum housing standard is an example of this (Bartussek, 2001). However, if the goal is to assess animal welfare at farm level or assess how animals perform in a specific production system, it is necessary to include animal based parameters. Two examples here would be the testing of alternative housing systems for laying hens in Sweden (Gunnarson et al, 1995) and certifying a specific welfare standard, as the Bristol Welfare Assurance Programme (Leeb et al., 2005). A welfare assessment system usable as an advisory tool should include information on specific and potential welfare problems their causes (Bonde, 2003), i.e. a combination of both environmental parameters and animal based parameters.

But besides using the information from different sources a welfare assessment system utilised for advisory purposes must also be transparent, providing farmers with a full understanding of the results (Main et al., 2003). Several approaches are presently applied for integrating welfare measures, and both 'scoring systems' and 'classic post-hoc interpretation of results' are methods providing transparency (Spoolder et al., 2003). 'Scoring systems' rely on a weighing of welfare indicators, and result in evaluating the level of welfare by predefined scoring sums, e.g. the TGI system. This provides a description of the welfare status with one or a few figures and make the systems very suitable for certification purposes. A hierarchical structure can be applied enabling assessment of welfare within different themes. In the 'classic post-hoc approaches' a range of indicators are measured, and the result of each indicator is used in a subsequent evaluation of welfare. Welfare indicators are not weighted beforehand, and no welfare limit is predetermined. Consequently the approach leaves the possibility of discussing the importance of specific welfare indicators under specific farming circumstances (Rousing, 2003). Examples of a classic post hoc approach are the ethical account for Livestock farming (Sørensen et al., 2001), developed into the DIAS Welfare Assessment System (Rousing, 2003; Bonde, 2003; Møller et al., 2003).

2.2 Methodological considerations

2.2.1 The welfare assessment system as a decision support tool in organic egg production

Sources of information

The purpose of developing a welfare assessment system was to provide the organic egg producers with a decision support tool to improve management. And this specific goal will influence the selection and weighing of welfare indicators and risk factors (Johnsen et al., 2001). If information on flock welfare status is to be converted into targeted management strategies, information on system and management must be available along with information on health and welfare status (Sandøe et al., 1997). This requirement comply with the DIAS welfare assessment system, where information is collected from four sources (1) the production system, (2) the management, (3) behaviour of the animals, and (4) animal health (Figure 2.1).

The DIAS welfare assessment system is based on a definition of welfare suggested by Simonsen (1996), where animal welfare is the combination of positive and negative feelings an animal experiences. The implication of using the animals subjective experiences to define welfare, is, that welfare cannot be measured directly. Instead welfare has to be assessed indirectly, by combining information on external factors influencing the animals and the animals' response in terms of health and behaviour.

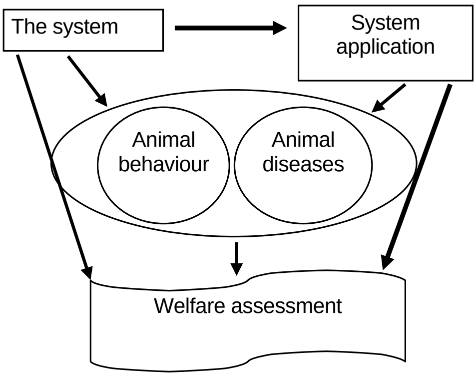

Figure 2.1 Sources of information for assessing animal welfare (from Sørensen et al., 2001).

Periodically reports

Management can change periodically and so can health and welfare problems, and this will be very pronounced in organic egg production, as the productions are all-in-all-out systems. If a welfare assessment system is to be used as a decision support tool, then the basis for decision making must reflect this variation. Consequently the welfare assessment must report the development of different welfare indicator, giving a dynamic portrait of the whole production period. The welfare assessment is therefore aimed at assessing welfare throughout the production period, and sum up the results in an annual report, which can provide the producers with a basis for their management strategies.

The welfare assessment report

In order to make the welfare assessment system a functioning decision support tool, the information obtained via farm recordings must be presented to the producers. And this must be performed in a manner that motivates and enables producers to focus on the relevant problems and risk factors. As concluded by Bonde et al. (2001) three kinds of information is important for that purpose: An overview providing a summery of the results, an evaluation of the welfare, providing the producers with a frame of reference and documentation of results, supporting the welfare evaluation. As documented by Sørensen et al. (1998) a motivation for inclusion of indicators should be part of the documentation ensuring that producers' appreciate the relevance of the welfare indicators.

Consequently the following structure was used, when developing the welfare assessment report: Chapter 1: summary and conclusions. Chapter 2-4: health, behaviour, system and management. Chapter 5: appendix, including the registration protocol. Each of the chapters 2-4 includes a motivation for including each indicator, the scoring method, documentation of results and an evaluation, providing the frame of reference. Breed specific standards was used as reference for weight and egg production. Norm figures from the efficiency control and farm data was used as a reference for mortality, and mandatory requirements for system capacity were presented together with farm data. The remaining indicators were only presented with results from other farms. The intention of using other farms as reference was to make the accomplishments of a producer the target for other producers; Thereby making aims and goals, set through the comparisons, realistic targets.

2.2.2 Developing the welfare indicator protocol

The process of developing a DIAS Welfare Assessment System starts by evaluating possible indicators relevant to describe welfare status or potential risk factors. The welfare indicators should satisfy the following requirements: (1) indicators should be relevant for animal welfare, based on scientific knowledge (2) Indicators should be able to reflect development over time (3) Indicators should be measurable on a commercial farm in a relatively cheap and easy manner (4) Indicators should be possible to use in decision support (Sørensen et al., 2001). As presented in Paper I, production specific criteria for organic egg production limits the choice of welfare indicators. The loose housed flocks make individual identification impossible and thereby eliminate the possibility of following focal animals. And in the large flocks, examination of single individuals must be of short duration in order to get sample sizes large enough to sufficiently describe the natural variation; as sample sizes rarely exceeds 100 individuals, indicators must have a prevalence of minimum 3% in order to be detected at all.

The welfare indicators are aggregated into a welfare indicator protocol, by evaluating each welfare indicator for its independent relevance, its marginal information value and its practical applicability (Rousing et al. 2001). The independent relevance refers to the indicators specific relevance in a welfare assessment. While the marginal information value is an evaluation of degree of unique information an indicator can provide. By evaluating the marginal information value it becomes possible to select the indicators that describe the welfare status best with the least amount of overlap. Finally the practical applicability is evaluated in terms of reliability. The independent relevance for the included welfare indicators is described in Paper I.

Due to the all-in-all-out production cycle of organic hens, the timing of monitoring is very important. Different health and welfare problems exists at different production periods (e.g. placement, peak of lay, end-production), therefore a thorough welfare assessment must cover a full production cycle. During the first two months of production the hens are exposed to a transfer (from rearing to production) and experience the physiological load of going into full lay. Consequently the first part of the production period imparts many stress factors, and therefore needs extra attention. In addition management, as well as health and welfare parameters not related to age, are also likely to fluctuate (Alban, 1997), and monitoring over a period enables detection of fluctuations not discovered in a one-point monitoring scheme. It was therefore decided to monitor the flocks every month in the beginning of the production period, and every second month after peak of lay: in weeks 20, 24, 28, 36, 44, 52, 60 and 68.

In order to enable evaluation of indicators and visiting frequencies, in a subsequent farm-testing, the initial welfare indicator protocol was more extensive that the final protocol was aimed to be. Inability to select the most appropriate indicators beforehand resulted in inclusion of indicators with possibly low marginal values (e.g. fear tests). And some indicators were included, although not suited for on-farm assessment, to investigate the need for additional information in the final welfare indicator protocol (e.g. autopsies revealing internal parasites and crop impaction). The welfare assessment protocol included the indicators selected via the described procedure, and methods were selected under the criteria that a flock recording could be concluded within ½ day. The initial registration protocol is presented in Appendix 1. And the motivations (i.e. independent relevance) for including the indicators are presented in Paper I.

In the following section some considerations regarding choice of key indicators or recording methods are presented.

Clinical examination: Methods for scoring plumage condition without handling the hens have been developed and applied in several studies (Bright et al., 2006; Bestman and Wagenaar, 2003), however an interest in including a measure of wounds, feet health and weight led to the decision of performing a clinical examination of a sample of hens in all flocks. So in all flocks a clinical examination was performed on 50 hens. A vide range of different plumage scoring systems exists, including both scorings of whole body and very detailed scorings of single body parts, as discussed by Kjær (1999). In the present study it was emphasised to use a scale including separate scorings of body part, but using an intermediate level of details. Methods and scales used for scoring plumage condition and foot health was adopted from Kjær (2000) and the scale is subsequently recommended by the LAY-WEL EU project (Tauson et al., 2005). Plumage conditions are scored on a 4-point scale at five different body parts: neck, breast, wings, back and tail. In addition wounds/scars are noted on a 3-point scale, modified after Gunnarson et al., (1995). Keel bone deviations ware scored on a 4-point scale using the method described by Gunnarson et al., (1995). In addition the hens' weight was recorded.

Mortality: Daily mortality and cause of mortality were recorded. Causes of mortality were specified as piling, predators or other causes. This was decided in order to attribute sudden large mortality figures to either piling or diseases. The estimated number of birds taken by predators were based on producers own records, and validated by information on numbers of hens purchased and sold.

Red mites: Mite traps or visual inspections are applied for estimating number of mites in hen houses. Mite traps act as mite hiding places during daytime, some designed to be removed and burned (Sokol and Romaniuk, 2006), while others aim at a quantification of the infestation level, however the most mentioned methods (incl. cardboard trap) is designed for laboratory analysis (Nordenfors and Chirico, 2001). Additional a very uneven distribution of mites in the house (Sokol and Romaniuk, 2006) could cause problems in getting reliable results from mite traps. So we chose to sample in 5 spots throughout the house. We created a mite hiding place, as suggested by Mauer (2002), using a plastic tube (d=3 cm) with a piece of paper inside. The paper (length 21 cm) was first crushed then rolled to fit the tube (length 30 cm). Traps were attached under the perches in all houses, equally distributed within the house. Traps were prepared with paper by the producer 3-7 days prior to farm visits.

Autopsies: In order to investigate weather indicators for crop impaction, vent pecking and intestinal parasites should be included; autopsies were performed on four hens in relation to every farm visit.

The farmers were asked to collect the last four dead hens, dying from other causes than piling and predators.

Use of the range area: In several studies use of the range area is measured as percentage of hens outside (Appelby and Hughes, 1991; Bubier and Bradshaw, 1998; Davison, 1986; Keeling et al., 1988). However, studies indicates that a vide range of factors influences the hens' use of the range area, including climatic factors, as discussed in paper III. The variable weather conditions are likely to increase the within-flock variation, making it difficult to compare farms with respect to use of range area. Visits in an advisory program cannot be scheduled in order to record use of range area only under specified conditions, as has been done in other studies (Bubier and Bradshaw, 1998). Consequently the varying weather conditions needs to be accounted for, if the number of hens outside is to be used in a comparison between farms.

The degree of within-flock variability was examined in 37 flocks from 5 farms, and the effect of climatic factors, flock size, and age was analysed in a generalised linear model, as described in paper III. The need for a sufficient number of observations for statistical analysis, made it impossible to use recordings from the development of the welfare assessment system. Instead we used data from an on-farm study aimed to examine the effect of artificial cover on use of the range area.

Fear tests: Fearfulness can be measured using different forms of behavioural tests, and often a distinction is made between stimuli-specific tests and tests reflecting general fearfulness, as discussed in Paper II. In the welfare assessment three tests have been included, to describe different aspects of fearfulness relevant in a welfare assessment: A novel object test, which is interpreted as measuring general fearfulness, and a sudden sound test along with an approaching human test, which are interpreted as being stimuli specific; both stimuli are likely to occur in commercial farms. In the approaching human test two different scales are applied for comparison. In order to evaluate if responses to any of these tests overlap enough to reduce the number of tests, the three tests were applied in 27 flocks, for an evaluation of agreement. Agreement was measured using Cohen's kappa, weighted to account for degree of difference. The method is described in details in Paper II.

In addition a tonic immobility (TI) test was performed on 247 hens in 8 flocks. The TI-test is also interpreted as measuring general fearfulness, and the purpose of the study was to investigate if the flock based tests reflect the individual hens' general level of fearfulness. Relationship between flock-based tests and TI-tests were analysed using one-way ANOVA with flock as a random effect.

The extra flocks used to obtain sufficient amount of data for at statistical analysis, came from 7 farms fulfilling the selection criteria employed in the selection for the welfare assessment evaluation. Furthermore, five of these farms agreed to participate in the TI-tests.

Aggression: An estimation of level of aggression can be obtained by observational studies or by clinical examination of pecking wounds on the hens' comb (Odén et al., 2005). If aggression is on a low level, then observational studies are likely to be unsuccessful, while wounds on the comb will remain longer and be more prevalent. On the other hand observational studies might offer an explanation of the aggression, if the aggression for instance is observed at specific locations. It was therefore decided to include both observational studies and a clinical examination of comb for a later evaluation. Number of aggressive pecks and number of bouts was recorded using the method applied by Kjær (2000). In order to relate aggression to resource availability aggressive pecks between hens were recorded by the nests and by the feeding line. However the daily activity patterns make observations of aggression by nests most likely before noon, and therefore required observation in this period. Aggression by the feeding line is more likely to be observed throughout the day, although it should be performed when feeding line starts running. Observations were performed in a defined area of 2 meters feeding line (both sides) and 3 meters platform by the nests. Recordings lasted 2 times 2 minutes for each location. For scorings of comb, se clinical examination.

Litter: The method for evaluating litter quality was developed together with technicians from DIAS, with scoring of humidity, structure and composition on separate scales.

Vegetation in the range area: the quality of vegetation in the range area was estimated by an evaluation of the percentage of respectively low vegetation, high vegetation, bushes, and trees. The method was applied to obtain information on vegetation height, as structures in the range area are known to influence the number and distribution of hens on range. In addition the types of vegetation were recorded in order to investigate weather this would provide additional information on quality of the range. The range area was divided into 4-6 sections in such a way that the average distance to the house was increasing with increasing section number. The sections were determined in agreement with natural borders in the area, though aiming to increase the section area with increasing section number.

2.2.3 Evaluation of the welfare assessment system

Evaluations of welfare assessment systems can be performed at different level ranging from evaluation of single indicators to the effect of applying the system on farms.

1 Single indicators can be evaluated for repeatability and reproducibility (e.g. Winckler and Willen, 2001)
2 Two or more indicators can be analysed in terms of exploring their interrelationship and precision (e.g. Berg and Sanotra, 2003).
3 Specific parts of the welfare system can be evaluated for completeness, as performed by Bonde (2003) evaluating the information value of the welfare indicator protocol.
4 And finally the system application can be analysed, as discussed by Verstegen et al. (1995) using comparison of farms with or without the system applied, or performed by Vaarst (2003) interviewing the producers as users of the system, or Alban et al. (2001) comparing the welfare assessment results performed by using different welfare assessment systems.

The method of evaluations can be performed as expert analysis (interviews, questionnaires), by statistical analysis depending on the topic evaluated or by experiences attained during application of the welfare assessment system.

In the present study it was decided to evaluate single indicators by statistical analysis due to uncertainty about robustness and degree of overlapping information (use of range area and fear tests). In addition an application of the welfare assessment system on five farms enabled a further evaluation of the practical applicability of each indicator and the usefulness of the welfare assessment report. The usefulness of the welfare assessment system and report were evaluated by interviews with farmers, corresponding to the evaluation discussed by Vaarst (2003).

Ten flocks from five different farms participated in the evaluation of the welfare assessment system. Flocks ranged in size from 1200–4500 hens per flock, and included five different breeds: Isa Brown Isa Babcock, Hyline Brown, Lohman Brown and Hellevad White. Flock data are given in Table 2.1.

The selection of farms was based on the following criteria: A maximum of 10 flocks, with approximately flock size of 3000 hens. Flock should start in the period January-June 2002, in order to complete the recordings within a 1½ year period. In addition producers should have minimum 3 years of experience and be able and willing to provide farm data and record daily figures on mortality and egg-production. Farms were selected with help from the Danish Advisory Service.

Due to visit restrictions caused by an outbreak of Newcastle disease in Denmark in the spring 2002, fewer visits were carried out in flock 9. Recordings were performed by four technicians from the Danish Institute of Agricultural Sciences (DIAS). All technicians received a one-day training course in the clinical examination and other recording procedures. Half way through the production period the producers were interviewed on management practices.

Table 2.1 Flock sizes, breed time of placement and slaughter for the 10 flocks involved in the evaluation of the welfare assessment system for organic egg production.

Farm	Flock	Breed	flock size	day-old, date,	Age at placement (weeks)	Age at slaughter (weeks)
A	1	Hellevad, White	3114	13/09-01	18 weeks	80-82 weeks
B	2	Babcock	4500	14/12-01	17 weeks	64 weeks
B	3	Babcock	4500	14/12-01	17 weeks	64 weeks
C	4	Hyline, Brown	3500	14/12-01	17 weeks	69 weeks
C	5	Hyline, Brown	3100	14/12-01	17 weeks	69 weeks
C	6	Hyline, Brown	1400 + 9 cocks	14/12-01	17 weeks	69 weeks
D	7	Lohman, Brown	4500	17/01-02	16 weeks	66 weeks
D	8	Lohman, Brown	3000	17/01-02	16 weeks	66 weeks
E	9	Isa Brown	3000	15/10-01	16 weeks	60-61 weeks
E	10	Isa Brown	3000	06/02-02	16 weeks	52-53 weeks

After finishing the recordings, welfare assessment reports were composed and discussed with the each of the five producers in a farm meeting with an advisor. The welfare assessment report was send to the producers prior to the meeting. At the two hour meeting on the farm, the results of the welfare assessment was discussed and the report used as an advisory tool. Within two weeks after the meeting a telephone interview with the producers was conducted by a third part in order to evaluate the producers' opinion on the welfare assessment system and the report. The outline of the interview was send to the producers prior to the call. The interview included a scoring of the indicators for relevance and presentation, on a 10-point scale, 10 being the best evaluation. In addition producers were asked to comment on the report as a whole, on the use of the results in terms of motivation for changes in management, on the possibilities for future use of the welfare assessment system, and on their perception of animal welfare.

2.3 Main results and discussion

The initial welfare assessment protocol, as presented in Appendix 1, is the result of the selection procedure described above. However studies undertaking to evaluate central indicators and experiences obtained during testing the welfare assessment system on five farms have led to a suggestion for an improved welfare assessment protocol (also presented in Appendix 1). Results of those studies and experiences are presented and discussed below. In addition the producers' evaluation of the report and system is presented and discussed.

2.3.1 Evaluating indicator 'use of the range area'

As presented in Paper II, use of the range area varied considerably between the 37 flocks used in the study, with flock averages ranging from 2-24%. However the within flock variation was equally high, ranging from 0-38%. The following factors had a significant effect on use of the range area: temperature (N=635, P=0.01), age (P=0.017), wind speed (P=0.008), precipitation (P=0.041) and season (P=0.0006). It was not possible to include either breed or quality of the range area in the analysis. Each of the modelled factors has a considerable effect on percentage of hens outside, with the most optimal conditions including a temperature of 17°C, medium-high atm. humidity and no wind (leaves move). In addition autumn was the most optimal season, and young flocks were more likely to use the range area.

In regards to structures in the range area, the study documented, that artificial covers in the range area had a significant effect on increasing number of hens outside. Percentage of hens outside increased from 9% of flock size in ranges without cover to 11% in ranges with cover (N=151, P=0.014). In addition the artificial cover had an effect on the distribution of the hens in the range area. Directing hens away from the section closest to the house (N=292, P<0.0001) and away from the middle sections of the range area (P=0.038).

In the ten flocks where the welfare assessment was applied, average use of the range area varied from 7.3% to 37.9% between flocks, suggesting a better utilization of the range area in these flocks. And the within-flock variation ranged from 0% to 52.6% in single observations. However compensating for different weather situation by applying the estimates achieved from the model to the data recorded during applying the welfare assessment system did not have the expected effect of lowering the within-farm variability. The standard deviation was lowered in two flocks, but increased in the remaining eight.

In conclusion, the weather conditions have a significant effect on number of hens in the range area, as discussed. Still a compensation for different climatic factors did not reduce the within farm variability. However very many other factors also influences the use of the range area e.g. genetics (Kjær et al., 2001), rearing (Grigor et al., 1995) predators (Keeling et al., 1988) and cover (Grigor and Hughes, 1993; Zeltner and Hirt, 2003). And it is very likely that there are also interaction effects, e.g. of weather and cover in the outdoor area, as the presence of cover could function as a wind breaker, or shelter from rain. But neither the influential factors nor likely interaction-effects are accounted for in the analysis. Consequently the measure 'percentage of hens in the range area' is a variable measure despite an attempt to compensate for weather differences, so another measure of use of range area should be applied. This other measure could be 'quality of the range area', measured as presence of vegetation and structures (bushes, trees, straw bales) in the different sections of the range area, as these are factors known to influence number and distribution of hens in the range area (Zeltner and Hirt, 2003; Grigor and Hughes, 1993; Paper III). However there will also be a large seasonal variation in this indicator, needed to be included when presenting figures in the welfare assessment report. In addition different management strategies as time of opening of pop holes, and feeding outside are likely to cause differences between flocks having the same 'quality of outdoor area'. It is therefore suggested to use 'quality of the outdoor area' in combination with 'wear/tear of vegetation'.

2.3.2 Evaluating indicator 'fear tests'

As presented in Paper III, the majority of flock-responses were not fearful in the 27 flocks used to study fear tests, only 7-24% of the responses showed some degree of fearfulness (scoring 3 or 4, see Figure 2.2). Agreement were poor between the flock-based tests (k_w = 0.0-0.24), and only slightly higher between the two different measurements of 'approaching human' (k_w = 0.34). The tests were performed at two different ages in all flocks, but also agreement between testing in week 35 and 55 were low (k_w = 0.0-0.41).

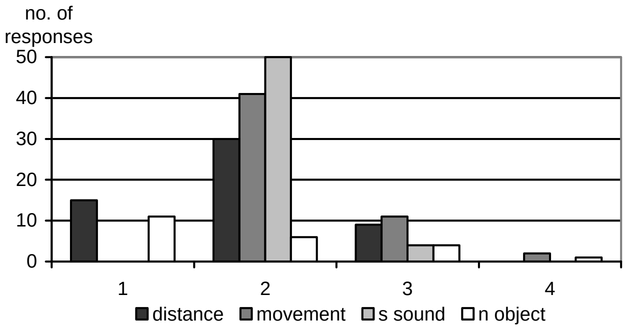

Figure 2.2 Distribution of responses to the tests 'distance', 'movement', 'sudden sound' and 'novel object'. All responses are scored on a 4-point scale, where 4 is the most fearful reaction. In 32 occasions flocks reached the time limit in the novel object tests and were excluded from the analysis.

TI-results differed much both within and between flocks. However the eight flocks where TI-tests were applied all responded in the same way to the flock-based tests. Consequently there was no relation between individually performed TI-tests and responses to flock-based tests.

The low agreement between the approaching human test, the novel object test and the sudden sound tests suggests that different stimuli in the tests elicited different responses, which is in concordance with the belief that avoidance tests are stimuli-specific. But although the approaching human tests were scored simultaneous on two different scales, the level of agreement between the recorded responses was relatively low. And this point to careful consideration when selecting scales.

In conclusion, comparing results from the flock-based tests gave no indication of overlap in responses. The indication of tests being stimuli specific emphasises the need for choosing appropriate test stimuli. Knowing that sudden/unknown sounds and humans are likely to be encountered by the hens during a production period both the 'sudden sound' and the 'approaching-human' test do seem appropriate. Also the reaction to the caretaker's presence could be included, as inspections and egg collections are daily routines, and fear of the caretaker therefore will be a daily stressor contributing to reducing animal welfare. But genetic differences will most likely influence the behaviour of the birds, emphasising the need for use of comparable breeds when presenting results in the welfare assessment report. And the reliability of the tests needs to be tested first. Consequently the indicator should be re-evaluated.

2.3.3 Evaluating indicators, from experiences with applying the welfare assessment protocol

The following section includes argumentation for inclusion, change or further evaluation of indicators, based on experiences when testing the welfare assessment protocol on five farms. Recordings from the application of the welfare assessment systems on the farms are presented in Appendix 2.

Mite traps: The mite traps gave a clear indication of seasonal variation in the infestation level. However two problems existed with the mite traps (1) practical problems including producers forgetting to fill in paper or the paper being taken by the hens. (2) questionable reliability of the indicator, as an interview with one of the producers showing results from traps (low-moderate infection) conflicting with the producer's perception of the level of infestation ("high level, making hens irritable and restless at night"). This illustrates the need for a thorough validation of the monitoring method. Presently no studies have reported results on reliable quantifications of infestation level, as monitored by traps. Therefore it should be considered to use a visual inspection of either house or bite-marks on hens.

Mortality: The different measures supplement each other well. By validating the daily recordings of mortality with invoices from purchase and slaughter it became apparent, that unrecorded losses to predators are probably higher than expected in many flocks, reaching 10% in four of the flocks.

Autopsies: The autopsies provided information of interest to some of the producers, especially 'crop impaction' and 'intestinal nematodes'. But as the autopsies are not appropriate for on-farm application, they should be substituted by two other indicators:
(1) Signs of crop distension when walking through the flock.
(2) Specific information on outdoor cleaning procedures between flocks, and pasture management, attained by interviews.

Clinical examination: Very little information on keel bone deviation and wounds on feet suggest that these indicators should be re-evaluated and possibly removed. In addition the first two clinical examinations provided only little information except for the weight measures, while the subsequent recordings provided good information on development of plumage condition and feet abscesses (Figure 2.3 and 2.4). The information on location of wounds provided some information indicating problems with resources, but results could be difficult to interpret.

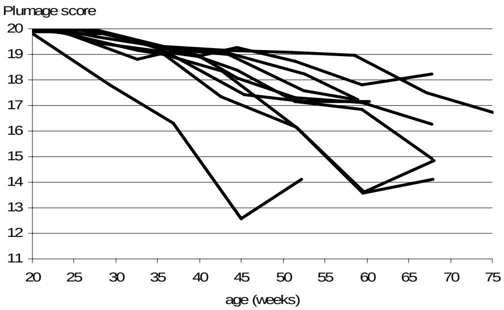

Figure 2.3 Development of plumage condition in ten flocks. Each line represents one flock. Scorings range from 20 for intact plumage to 5, for severely damaged plumage.

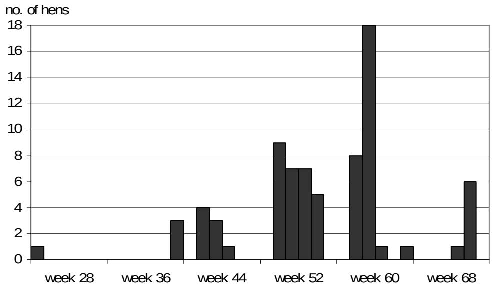

Figure 2.4 Number of hens with recorded feet abscesses, of 50 examined. Each bar represents recordings in one flock. Recorded at weeks 28, 36, 44, 52, 60, and 68.

Aggression: Recording errors in the observational studies made it impossible to compare results from observational studies with recording of comb wounds. However the need for observation at specific times of the day, and the consequent requirement of a specific visiting period makes it easier to use comb wounds as indication of aggression. Recordings of comb wounds should be used in combination with information of accessibility of resources.

Management interviews: More specific information on cleaning procedures between flocks and amount of roughage per hen per day should have been included.

It should be noted, that the process of developing the welfare assessment protocol is an ongoing process, as new indicators or methods of measuring are presented through other studies. Presently the Welfare Quality project which is aimed at developing useful assessment methods (Anon. 2004) is likely to result in re-evaluation of some of the indicators.

2.3.4 An improved welfare assessment system

The initial welfare assessment was designed to take 3½-4 hours per flock, and with the majority of producers having at least 2 flocks, the farm visits would last minimum one day. Seven visits were scheduled per producer, although some had eight visits due to prolonged production period. The prototype of the welfare assessment system took additionally 3 days, including time spent on measuring the capacity of resources at the first visit (1½h), the interview half way through the production period concerning management routines (2h), collecting and typing in data from producers and data from farm visits (1 day), writing the report (1 day) and finally presenting of the report (2½h). Consequently this prototype will be far too expensive to apply on commercial farms, thus requiring a reduction of the system.

There are several ways to reduce time, as discussed by Sørensen et al (in press). Slimming the present welfare assessment system could include: fewer visits, faster/other methods of scoring, more precise interview questions regarding management routines and using an existing template for the writing of reports.

As documented in the welfare assessment report, animals' health and welfare status can vary considerable over time. And the monitoring frequency provided a good basis for evaluating fluctuations in the flocks' welfare. However, the seven farm visits significantly increases the cost of the welfare assessment system, it is therefore suggested to reduce number of recordings to four: when the hens are of age 20, 24, 29 and 55 weeks. In addition it is possible to differentiate the use of some measures: Plumage condition needs not be evaluated in week 20, and foot health needs not be evaluated until week 44.

The clinical examinations takes about 1-1½ hour per flock, and consequently it should be considered whether this time could be reduced by either reducing sample size or changing method. It is possible to reduce sample size. In the Bristol Welfare Assurance Program individual hen examination is performed on 20 individuals (Leeb et al., 2005). However the reduction of sample size will threaten the precision of the data, and thereby the validity of the results, as discussed by Bright et al., (2006), who suggests minimum 100 hens for precise evaluation of plumage and weight. In addition the chance of finding less prevalent problems and diseases will be reduced with a reduced sample size. In the present study wounds on comb and impaired foot health are examples of low prevalent indicators that would be affected by a reduced sample size, with the consequence of welfare assessment reports being unable to show differences between flocks. Alternatively methods of scoring plumage condition without handling the hens (Bright, et al., 2006; Bestman and Wagenaar, 2003) could also reduce the time span; however in this case information on weight, feet health, and wounds would be lost. These informations are valuable in the welfare assessment report and the clinical examination of minimum 50 hens is not changed. However the scoring of the range area could be reduced, as much time (½h) was spent on describing the types of vegetation. In addition time could be reduced by substituting observation of aggressive behaviour with the clinical examination of wounds on comb and by not shipping hens for autopsies, although the autopsies should be substituted by an evaluation of hens in the stable. With the suggested changes the farm visits will have duration of about 2½-3 hours.

The interview time with farmers could be reduced considerable if providing the farmer with a list of specific questions. This will also ease the comparison between farms. Finally the report creation will become faster if using an existing template. Consequently a welfare assessment in two flocks can be performed in four days (including initial measurements, interview and presentation), plus additionally one or two days for collecting and typing in data and creating the report.

2.3.5 Evaluation of the welfare assessment report

The welfare assessment reports included six chapters: (1) background and aim, (2) summary and conclusions, (3) health and mortality, (4) system and management, (5) behaviour, (6) appendix. The appendix include recording protocol, list of all autopsies, description of diseases, weather conditions at visits and sketch of range area. An example of a welfare assessment report (in Danish) is included in appendix 2.

The welfare assessment report was presented and discussed with the producer at the farm after finishing the data collection. This meeting highlighted the advantage of the benchmarking system applied in the report, allowing producers to compare their own results with other producers. Nevertheless, only five producers participated and comparisons were made with caution due to the differences in breed. An account of the results for some of the indicators (Table 2.2) showed that all producers could improve some aspects of the production, and no producers scored low on all indicators. This facilitated a discussion of aims with the production in terms of different aspects of welfare.

Table 2.2 Each column represents the results from scoring one indicator. The results from the 10 flocks are ranked, showing the best results as rank 1. The best results in each indicator are marked by shading the cells (rank 1 and 2).

	foot health	plumage	% outside	wounds	fear test	litter quality	perches
flock 1	1	1	8	1	5	1	7
flock 2	3	3	5	6	3	2	2
flock 3	4	3	2	5	1	2	3
flock 4	1	4	4	4	6	2	4
flock 5	1	5	3	4	4	3	5
flock 6	1	2	1	9	2	3	1
flock 7	2	7	7	8	2	4	7
flock 8	1	7	6	7	1	5	8
flock 9	2	4	9	2	7	4	6
flock 10	1	6	10	3	8	6	2

In a telephone interview the five producers (A-E) were asked to state their general impression of the welfare assessment, whether it would/could motivate them to change management, and finally their evaluation on the welfare assessment as an advisory tool.

General impression of the welfare assessment report

The general impression from the telephone interview was, that producers found the report relevant and thorough, and that the comparisons with other flocks were interesting. One of the producers (E) could not relate to the many welfare indicators and suggested that low mortality and good plumage should be sufficient measures of welfare; however the exact opposite view was expressed by (A). The producers differed much in their opinion on what was better or worse in the report. Comments included a positive evaluation of all main chapters, but too much text in background, and too few conclusions and suggestions for improvement in the summary. Producers also stated that they could use further information on light, roughage (amount per hen) hygiene and amount of time (daily) used by producers in managing the flocks. Two producers (B and C) compared the welfare assessment system to a scoring-based welfare assessment system, recently introduced in Danish organic egg production, and valued the more thorough treatment of indicators and transparency of results presented in this study.

Motivation to change management

Three producers (A, B and E) specifically stated that they intended to change management after seeing the results in the report, or used the report to look for points to change. It is noticeable that (A), which primarily expressed interest in plumage and mortality, actually decided to change operational management, aiming to improve the litter quality, in response to the results shown in the welfare assessment report. This supports the idea of motivation by using other producers in benchmarking. On the other hand producer (D) could not use the results of the other producers in anyway as he always aimed at improving results, regardless of the results of others.

Possibilities for future use of the welfare assessment system

When asked, in which situation the producers normally use the advisory service, all replied “as trouble-shooting”. This is in accordance with interviews exploring the same welfare assessment system in dairy, pig and mink production (Vaarst, 2003). And it is also reflected in the statement from (A), (B), (D), and (E) expressing the wish of an advisory service with fast response/advice at visits. However (A), (B) and (C) could see a possibility for an integrated package evaluating all aspects of the production (productivity, feeding strategy, welfare etc.), but expressed concern about the costs.

The need for advisory service should be considered in relation to the producers’ own experience. In the present study all producers had a relatively long (>5 years) experience with organic egg production. And one producer (B) could see a possibility for using the welfare assessment system for adjusting management for new producers.

Relevance and presentation of indicators

In the telephone interview, the producers scored the figures and tables in the welfare assessment report for relevance and presentation. A 10-point scale was used, with 10 given to the best result. As illustrated in Table 2.3, producers differed greatly in their opinion on what is better or worse in the report. But in general foot abscesses, red mites and fearfulness scored low on relevance, while mortality and plumage condition scored high. Low scores on relevance should reflect the producers view on a specific subject, but could also be related to a poor explanation of welfare relevance. Presentations could be improved of system/management, especially roughage and litter quality. In addition presentation of animal behaviours could be improved.

Table 2.3 Producers (A-E) scorings of welfare relevance and presentation of the indicators included in the report. Each row in this table refers to a figure or table in the report. Scorings were performed on a 10-point scale, where 10 express the best result.

	Welfare relevance					Presentation				
health, mortality	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**
mortality curve	10	8	10	10	10	8	8	8	10	10
autopsies	5	8	5	9	5	8	8	8	10	10
mortality, producers records	10	8	9,5	10	5	8	8	8	10	10
% lay	10	8	10	8	9,5	8	8	8	10	10
floor eggs	7	7	4,5	6,5	4,5	8	8	8	10	10
plumage, body parts	10	9	10	8,9	10	8	8	8	10	10
plumage, total	10	9	10	10	10	8	8	8	10	10
weight curve	7	9	10	7	9,5	8	8	8	10	10
weight uniformity	7	9	10	9,5	5	7	8	8	10	10
Foot abscesses	6	8	5	8	3		7	8	10	10
red mites	6	8	5	7,5	3		8	8	10	10
system/management										
Resource capacity	10	9	10	5	3		6	8	10	10
litter structure	7	9	10	9	5	5	7	8	10	10
litter moisture	7	9	10	10	5	5	7	8	10	10
litter, composition	7	8	10	8	10	5	7	8	10	10
roughage	10	9	10	6,5	10	7	4	8	10	10
Hygiene	7	7	10	6,5	8,5	8	8	8	10	10
Behaviour										
fearfulness	6	7	5	3	3	10	8	8	10	10
Wounds, comb	10	9	5	9,5	3	10	6	8	10	10
Wounds, body	10	9	5	9,5	3	10	6	8	10	10
% outside	10	8	10	10	4,5	7	6	8	10	10
% outside	10	8	10	10	4,5	7	6	8	10	10
distribution outside	10	8	10	6,5	4,5	7	6	8	10	10
Producers' mean scoring	8.3	8.3	8.4	8.2	6.0	7.6	7.1	8	10	10

In conclusion the producers' evaluation of the welfare report was satisfactory. However the welfare report should be trimmed, in terms of removing excess text. Furthermore, we need to specify the importance of some of foot health, red mites and fearfulness as welfare indicators. In addition the presentation of behaviour and system/management also need improvement. The welfare assessment system seemed to work in relation to motivation, although the producers expressed concern about the practical applicability of the system: Costs could easily be too high for the extensive systems, and the welfare assessment should possibly be included in an evaluation of the entire production.

3 The HACCP-like system

3.1 Introduction

Hazard Analysis and Critical Control Point (HACCP) is a management tool aimed at controlling risk factors for food hazards. It is a proactive system that focuses on prevention rather than relying on end-product testing (Sperber, 2005). HACCP systems are internationally credited and adopted by Codex Alimentarius, providing uniform guidelines for food safety (FAO, 2001). Consequently HACCP is widely applied within the food industry and mandatory in several countries (Ropkins and Beck, 2000).

The construction of HACCP systems is based on seven principles, centred on defining and monitoring Critical Control Points (CCPs). A CCP is identified as a step at which control can be applied and is essential to prevent or eliminate a food safety hazard or reduce it to an acceptable limit (FSIS, 1997). However HACCP systems are part of a two-level structure, as prerequisite programs are applied to secure basic conditions (FSIS, 1997). Prerequisite programs include Good Manufacturing Practice, Good Hygiene Practice, Good Management Practice etc., and can be applied in HACCP-like systems, including control and documentation procedures.

The seven HACCP principles:

1. Conduct a hazard analysis
2. Determine critical control points (CCPs)
3. Establish critical limits (alarm values)
4. Establish a system to monitor control of the CCPs
5. Establish the corrective action to be taken when monitoring indicates that a particular CCP is not under control
6. Establish procedures for verification to confirm that the HACCP system is working effectively.
7. Establish documentation concerning all procedures and records appropriate to these principles and their application

The use of HACCP as a quality assurance system in many industries interacting with animal husbandry has inspired to the application of HACCP in the primary production. Due to the different qualities of food processing industries and animal husbandry systems, these systems need to adopt slightly different methodologies and definitions and are often termed HACCP-like or HACCP-compatible (Noordhuizen and Metz, 2005). In addition HACCP-like systems for the primary production often focuses on issues other than food safety, as pre-slaughter stress in pigs (Borell and Schaffer, 2005), calf rearing management (Boersema, 2006), quality assurance on dairy farms (Silva *et al*., 2006) and herd health management in organic pig production (Bonde and Sørensen, 2004).

The advantages of applying HACCP for quality assurance of health and welfare in husbandry systems relate to the advantages of a more preventive approach as opposed to a curative approach, which applies well with the organic principles (IFOAM). But also because consumers demand quality assurance, and with the HACCP documentation procedures and preventive approach HACCP is highly suited for certification purposes. In addition HACCP is already implemented in the food processing companies so adopting HACCP to the primary production enables an integrated quality assurance program from farm to table (Noordhuizen and Metz, 2005).

Developing HACCP systems is a very time consuming task that requires detailed knowledge of food hazards and control of the associated risk factors. The comprehensive task of performing the hazard analysis and establish critical limits and monitoring schemes have led several authorities to develop generic HACCP systems including the first 3-5 principles (FSIS, 1997; CFIA, 2005). These systems are meant as guidelines for the development of operational HACCP adapted for specific productions.

3.2 Methodological considerations

The method used for developing the generic HACCP system is described in Paper IV. In the present chapter fundamental methodological consideration concerning study design, sampling and measures are presented.

3.2.1 Choice of method

Two different approaches appeared available to perform the risk analysis/choose hazard and risk factors for the HACCP system: a literature review or an expert panel analysis. An epidemiological analysis was impossible due to lack of sufficient data material.

The main advantages of a literature review are the possibility to include inputs from many sources in the risk analysis. In contrast an expert panel analysis completely depends on the limited number of experts contacted and agreeing to participate. However an expert panel was chosen in this study because (1) Part of the analysis included comparing hazards and risk factors, and subsequently selecting the most important. The information on severity of the hazards and risk factors are not available in literature in a magnitude that allows for solid comparisons. (2) In literature reviews some hazards or risk factors risk being overlooked due to their character. For instance hazards and risk factors relating to system maintenance are likely to be less represented in research papers than hazards and risk factors relating to infectious agent or animal behaviour. Therefore quantifying expert’s opinions and including researchers as well as advisors with practical experience as experts was chosen as the best method.

We chose to use a series of interrelated questionnaires to quantify the expert’s opinions. The method used in this study has many similarities with a traditional Delphi method including some basic elements: (1) An expert panel, most often anonymous to each other. (2) A series of questionnaires for the expert panel, where the outline of each questionnaire is dependent on answers to the previous questionnaire, and (3) Evaluation of consensus among the experts (se e.g. Keeney et al., 2006). But besides comprising of a series of interrelated questionnaires, a traditional Delphi analysis also involves circulating the experts’ replies until a defined level of consensus is reached in each question (iterations). The type of analysis used in this study is sometimes referred to as a quasi-Delphi (EC, 2006) or a modified Delphi (Katcher et al., 2006) due to the omission of iteration on the replies. Regardless of terminology the basic approaches enables the use of general experiences describing advantages and disadvantages of the procedure.

The use of a Delphi approach has several advantages over face-to-face expert panel discussions. The anonymity of the participants reduces the bias which can be caused by dominant outspoken persons. And the email communication spares travel time and expenses and leave opportunity for the experts to fit in the task of answering with their other work. However among the disadvantages are risks of high drop out rates, uncertainty whether experts have the correct understanding of the questions, and the risk of sloppy work as the anonymity might result in lesser obligation compared to face-to-face panel discussions (as discussed by Hanafin, 2004 and Keeney et al., 2006). The following steps were used in an attempt to reduce the number of drop outs (Hasson et al., 2000; Keeney et al., 2006): (1) Experts accepted participation by responding to an email, where the study and aim was described. (2) Experts missing deadlines were given a reminder one week after the deadline in the first three questionnaires. Since the fourth questionnaire was the last, it was possible to send a second reminder to experts still not responding. To ensure correct understanding of the questions all responses and comments were checked to see if there were any obvious misunderstandings. Subsequently a high level of agreement in the responses would also indicate a common understanding of the questions.

3.2.2 The expert panel

The result of the expert panel analysis is an aggregation of the experts' assessment of a given problem; therefore the choice of experts is highly important. To ensure that experts had the same field of expertise and the same cultural and legislative background, experts were included on the basis of two criteria:

1. Experts should be researchers and/or advisors with experience in on-farm welfare in commercial free-range or organic egg production systems.
2. Experts should be from EU countries geographically proximal to Denmark.

To avoid bias only one expert could be included per research institute.

To avoid the risk of missing important risk factors it was crucial, that the expertise in panel covered the entire topic 'health and welfare in organic egg production'. The drop out rate was expected to be relatively high (Gordon, 1994; Keeney et al., 2006) although if possible limited to a maximum of 30% to avoid bias (Thrusfield, 1995). So, with the assumption that 10 experts sufficiently could cover the topic, it was decided to include minimum 15 experts in the panel. The degree of overlap in the suggested risk factors (in Questionnaire 3) was used in an evaluation of whether the panel sufficiently covered the topic.

It was considered to have two or three parallel expert panels: researchers (veterinarians and behavioural scientists) and advisors. This would have allowed for testing agreement between groups thereby validating the results. However due to problems recruiting a sufficient number of experts the analysis was performed with only one panel.

3.2.3 Composition of the questionnaire series

When planning Delphi analysis it is recommended to have a maximum of 2-4 rounds to reduce the time frame and limit the drop out rate (Keeney et al., 2006).

Table 3.1 Questionnaire material received by the expert panel, description of the expert panels' tasks in each of the four questionnaires, and scales for scoring the hazards and risk factors in Questionnaire 1 and 3.

	Material send to the expert panel	**Expert panel task**	**scale for scoring severity / frequency**	
1	The panel participants received a list of 34 health and welfare problems seen in Danish organic egg production.	Score each problem with respect how severe is it for the animal's welfare to be subjected to the problem (severity) and how often an animal in the organic egg production is subjected to the problem (frequency).	5	very severe / very frequent
			4	severe / frequent
			3	moderate / regular
			2	less severe / rare
			1	not severe / very rare
2	The panel participants received a list of the selected health and welfare problems	List all possible risk factors for each of the selected health and welfare problems.		
3	The panel participants received a list of all risk factors suggested for each of the selected health and welfare problems.	Score each risk factor with respect to how severe the risk factor is for developing the welfare problem (severity), and how frequent the risk factor occurs in the production (frequency).	4	severe / frequent
			3	moderate / regular
			2	less severe / rare
			1	not severe / very rare
4	The panel participants received a list of the selected risk factors.	List all possible control points as detailed as possible for each risk factor, and suggest critical values for each control point.		

Since the aim of the expert panel analysis was to select the most important health and welfare problems (hazards) and risk factors and suggest critical limits for the control points it was decided to have four rounds of questionnaires: (1) scoring a list of health and welfare problems, (2) suggesting risk factors, (3) scoring the risk factors, and finally (4) suggesting control points (Table 3.1). This was the maximum recommended number of rounds, so it was decided to avoid iterations on the scorings. This approach has previously been used by Katcher et al. (2006).

A general concern with written questionnaires is whether all participants have the same perception of the text in the questionnaire (Nielsen et al., 2004). Having the same perception of the questions and the same basic knowledge is a prerequisite for obtaining a certain degree of consensus in the responses. So when constructing the questionnaires the accompanying letter should explain the questions and ensure that the text was specific and unambiguous. On the other hand too much explanation might cause the readers to skip the text and proceed directly to the questions. Therefore it was decided to describe the intend of the questionnaire in the first letter and keep the amount of text in the following accompanying letter to a short description and an example in questionnaire 2 and 4, as illustrated below.

Questionnaire 2

> In Questionnaire 2 you are asked to suggest risk factors for the chosen welfare hazards. Risk factors are elements in the production system or the management that increases the risk of developing a welfare hazard. In other words risk factors are reasons for the occurrence of the welfare problem. This session will act as a brainstorm; you do not need to consider the importance of the risk factors.

Please try to be specific when suggesting risk factors

For example:

Welfare Problem	Examples of risk factors
Stress	Too early in peak of lay due to light programme with too much daylight
	Insufficient access to resources (water, feed….)
	Unexpected incidences (predators, mechanically errors – feed, nests…)
	Fear of humans/caretaker
Internal parasites	Insufficient cleaning of outdoor area, near house
	Access to manure in litter/bedding material

Questionnaire 4

In Questionnaire 4 you are asked to suggest control points and critical values for the selected risk factors. Control points are elements of the production that needs to be monitored to prevent the risk factor for appearing, and critical values are (if possible) the value that separates ‘good’ from ‘bad’.

Please try to describe or specify practical control points and methods useful for on-farm assessment - as specific as possible.

For example:

Welfare hazard	Risk factor	Control points and critical value
Foot burns	Too much manure in litter	Check litter twice a week. Maximum 20% manure in top layer of litter.
Internal parasites	Insufficient cleaning of outdoor area near house	Change top 10 cm of earth in 0-15 meters distance from pop holes, between flocks.

3.2.4 Inclusion criteria

The scope of the expert panel analysis and avoid response fatigue in the questionnaires a maximum of ten health and welfare problems was set to be the limit for the further analysis. Additionally the aim was to have an average of 3-4 risk factors per problem, but imposing the criteria that all hazards have minimum one risk factor.

The selection procedure was based on the relative importance the hazards and risk factors, defining importance by scorings of severity and frequency. This corresponds to the evaluation of consequence and probability of occurrence of risk factors outlined in Danish Standard for HACCP systems (2002). The HACCP system was aimed to control the most severe hazards, so in the analysis the selection of hazards were based first on severity and secondly on frequency. However in the selection of risk factors the value of severity and frequency were more balanced. The method of selection resembles the method used by Noordhuizen and Metz (2005), but weighing the severity-scores slightly higher than the frequency scores: The scorings of severity was squared and multiplied with the scorings of frequency and inclusion sequence was based on the values of each risk factor. Inclusion started with risk factors scoring more than 40 points and continued with including the highest scoring risk factors (se Figure 3.1) until all health and welfare problems had minimum one selected risk factor, and average numbers of risk factors per problem were minimum 3.

Severity							
4	16	**10**	**4**	**1**	**1**	**1**	**1**
3.5	21	14	**9**	**6**	**2**	**1**	**1**
3	25	20	15	11	**7**	**5**	**3**
2.5	29	24	20	17	13	12	**8**
2	33	30	26	23	22	18	16
1.5	38	35	23	31	28	27	25
1	41	40	39	37	36	34	33
	1	**1,5**	**2**	**2,5**	**3**	**3,5**	**4** **Frequency**

Figure 3.1 Selection order of the suggested risk factors. Risk factors in squares numbered 1 are included first. Then inclusion proceeds with risk factors in squares with the lowest numbers until all problems have minimum one risk factor and an average of 3 risk factors/problem.

3.2.5 Defining consensus

A traditional Delphi analysis involves circulating the experts' replies until a consensus is reached in each question (iterations). But although Delphi analyses are widely applied and the level of consensus is used as a success criteria there are no standard consensus definition (Powel, 2003). The applied method of calculation and exact limits depends on the different scales used and aim of the study. The interquartile range (IQR) is a frequently applied measure, using limits of 0.5-2 to differentiate between consensus and no consensus (e.g. Redmond et al., 2006; EC, 2006; Wicklein, 1993). But also the standard deviation or a certain percent answers within a predefined limit are used to define consensus (e.g. Hardy et al, 2004; Hanafin, 2004). In the present analysis consensus was calculated using the interquartile range, as a stable measure of dispersion. With the following definitions: IQR=<0.5: strong consensus, 0.5<IQR<=1: moderate consensus, IQR>1: no consensus. This definition has previously been used to evaluate scores on 5-point scales by Marchal et al. (2004).

3.2.6 Composition of the generic HACCP-like system

A HACCP system for the food processing industry is based upon prerequisite programs and the critical control points elucidated by the hazard analysis (FAO, 2001). However in many organic egg production systems the prerequisite programs are not implemented in a systematic way with a documentation procedure. The lack of systematic implemented prerequisite programs has implied that the generic HACCP system includes all control points, regardless of the fact that some should have been controlled by prerequisite programs. Consequently a generic HACCP-like system was constructed based on all the suggested control points in questionnaire 4, evaluated for practical applicability.

The catalogue consists of Control Points (CPs) specifying points to monitor where a specific level of quality is required. In the catalogue CPs are described with monitoring frequencies, alarm values and corrective actions.

3.3 Main results - an overview

This chapter presents the essential results from the development of the generic HACCP system. Results are presented more thoroughly in Paper IV.

3.3.1. The most important hazards and risk factors

Table 3.2 Selected health and welfare problems and risk factors. Selection based on median scorings of severity and frequency.

Health and welfare problems			**Risk factors**		
	median scorings			**median scorings**	
	severity	**freq.**		**severity**	**freq.**
Predators	5	3	Insufficient closing of pop holes at night	4	2
			Security of house/holes in the house	4	2
			Poor fencing (not digged in, no electricity, holes, high grass)	4	3
Cannibalism	5	3	Poor diet (unbalanced deficient: protein, essential amino acids, methionine, lysine, salt)	4	2.25
			No elevated perches / lack of adequate perch use	4	2
			Low stimulation (poor quality litter, no roughage, no grains in litter, no access to outdoor area)	4	3
			No action at first signs of cannibalism	4	2.25
			Occurrence of wounds	4	2
			Feather pecking	4	3
			Poor management of pullets in rearing (housing, perches, light, weight gain, human contact)	3.5	3
			Physiological stress at onset of lay (eggs too big, low body weight, too young, neg. energy balance)	4	3
Piling	5	2	High stocking density	3.5	3
			Nervousness / fearful hens (are frightened by unexpected incidences / sudden novel stimuli)	4	2
			Not enough habituation to environmental stressors during rearing	4	3
Bone fractures	5	2	Poor/rough handling during catching	4	3
			Rough handling during production period	4	2
			Poor diet (vitamin D and Ca deficiencies, P/Ca balance)	4	2
			Bad /broken equipment and equipment with sharp edges	4	2
Crop impaction	5	2	Feed deficiency, which make hens eat everything	4	2
Blackhead	5	2	Poor pasture management (rotation, exsiccation, removal of top-layer near house, improper drainage)	3.5	3
			Poor cleaning between flocks	4	2
Pasteurellosis	5	2	No disease identification when mortality rises (=> no vaccination of the next flock)	4	2.5
			No vaccination of 'high risk' flocks	4	2
			Poor cleaning between flocks	4	2.5

Table 3.2 – continued. Selected health and welfare problems and risk factors. Selection based on median scorings of severity and frequency.

health and welfare problems			Risk factors		
	median scorings			median scorings	
	severity	freq.		severity	freq.
Hunger	5	1	malfunctioning feeder system	4	2
			electricity failure	4	2
			Pathology (e.g. crop distension)	4	2
			Illness/injury preventing movement or preventing eating	4	2
Thirst	5	1	Not enough drinkers	4	2
			Malfunctioning water system (pipes, drinkers)	4	2
			Insufficient supply (e.g. pressure, electricity failure)	4	2
			Thermal stress (high temperature)	4	2
			Poor accessibility of water (design of housing and equipment)	4	2
			Animals too small to reach drinkers	4	2
			Illness/injury preventing movement or preventing drinking	4	2
Red mites	4	4	High temperatures	4	3
			Poor house and furniture design providing hiding places for mites	4	3
			Insufficient cleaning and disinfection between flocks	4	3
			Poor hygiene during the production period	4	3
			Delayed treatment if number of mites rises	4	3
			Underestimation of consequences if number of mites rises	4	3

There was consensus in 77-91% of the suggested problems and risk factors, and 80-100% of the selected. Strong consensus was reached in 14.7-34.4% of the suggested problems and risk factors and 20-39% of the selected (Table 3.3).

Due to the change from 5-points scales for scoring problems to 4-points scales for scoring risk factors, there was a higher chance of meeting the consensus criteria when scoring risk factors. This pattern is seen in the scoring of frequency, however when scoring severity the percentage of strong consensus increased, while the percentage of moderate consensus decreased.

Table 3.3 Percentage of scorings with respectively high (IQR<=0.5), moderate (0.5<IQR<=1) or low degree (IQR>1) of consensus, when scoring severity and frequency in the health and welfare problems and the risk factors.

	Health and welfare problems		Risk factors	
	all	**selected**	**all**	**selected**
Severity	(N=34)	(N=10)	(N=154)	(N=41)
% strong consensus	14.7	20.0	28.6	39.0
% moderate consensus	76.5	80.0	48.7	56.1
% no consensus	8.8	0	22.7	4.9
Frequency				
% strong consensus	20.6	20.0	34.4	29.3
% moderate consensus	58.8	60.0	54.5	61.0
% no consensus	20.6	20.0	11.0	9.0

3.3.2 The expert panel

A total of 18 experts from 9 different Northern European countries participated in the questionnaire series. The response rate dropped from 94% in Questionnaire 1 and 2, to 67% in Questionnaire 3 and 72% in Questionnaire 4.

With a smaller panel size in the last two questionnaires the risk of missing important risk factors increased. And analysis showed that 17% of the 41 risk factors selected for further analysis in Questionnaire 3 were suggested by only one person in Questionnaire 2 (figure 3.2).

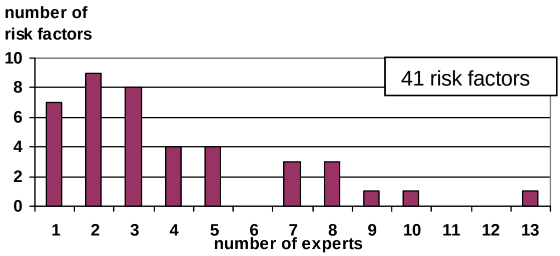

Figure 3.2 Number of selected risk factors initially suggested by respectively 1,2,3-13 experts

3.3.3 The generic HACCP

A total of 390 control points were suggested by the expert panel, and by eliminating doublets within risk factors and control points not applicable for practical purposes, the number of control points were reduced to 237. As seen in Table 3.2 one risk factor is sometimes related to several problems e.g. poor cleaning is a risk factor for pasteurellosis, red mites and blackhead. This leads to multiple suggestions of the same control points. Additionally the same control points might be suggested for different risk factors, e.g. the control point ‘alarm signalling electric failure’ applies to both insufficient water supply (thirst) and electric failure (hunger). Consequently the final list of suggested control points was reduced to 99 different Control Points (CPs).

Most often the suggested alarm values were imprecise using terms as ‘appropriate’ or ‘sufficient’, while many other simply referred to mandatory standards. For the completion of the generic HACCP-like system (Appendix 3), mandatory system requirements are added as alarm values in cases where specific alarms values are not suggested by the expert panel.

It is often possible to secure a risk factor by monitoring different aspects of the production, and if suggested by the expert panel both control points are included in the catalogue. Additionally some control points depends on the actual situation on the farm, e.g. presence of alarms or not. So the catalogue is meant as input to the farm specific HACCP-like system. A subsequent adaptation of the generic HACCP to the specific farming system would include selecting of appropriate CPs suitable for the specific production; Aiming to reduce the number of CPs to an absolute minimum in order to construct an operational system.

3.4 Evaluation of the HACCP system

It is questionable whether the procedure used in questionnaire 1 resulted in the selection of the most important health and welfare hazards. The design of the first questionnaire left no opportunity for the experts to include combined effects of different heath and welfare problems, although the combination of several 'minor' stress factors can result in severe welfare problems. In addition the experts clearly rated health and welfare problems with high morbidity as the most severe. Whether this is accountable to an evaluation of the welfare consequences of short term exposure resulting in death as opposed to long term exposure causing general ill thrift, is open for discussion. It could also be related to the general association of the term 'severity', interpreting it as 'risk of immediate death'.
Consequently a more appropriate method of choosing the most important hazard could be a kick-of workshop or a traditional Delphi analysis aiming to reach consensus on the specific question 'choice of most important health and welfare problems to control in a HACCP system'.

As expected the response rate dropped considerable, however with intense follow-up in the fourth questionnaire the response rate was maintained at 70%, which is the recommended minimum to avoid response bias (Thrusfield, 1995). However as a consequence of the high drop out rate there was an increasing risk of missing important risk factors. And analysis of the responses shows, that 17% of the selected risk factors in Q3 were suggested by only one expert in Q2. This appears to be a relatively low degree of overlap between experts, indicating that including more experts in the panel might have increased the validity of the analysis. Still there was a high level of agreement in the scoring of both severity and occurrence of the risk factors. Consequently, this level of consensus supports the fact that relevant risk factors were chosen.

The experts suggested a vide range of control point giving a solid starting material for adapting the HACCP system to individual farms. The choice of control points depends on the specific conditions on the farm and could also relate to the caretakers preference of animal based or system based indicator. A general reluctance to set alarm values probably reflect the fact that many control points in the production have a continuous range of values, ranging from 'perfect condition' to 'unacceptable', and setting a specific value separating 'good' from 'bad' is very difficult. Most experts simply referred to standards given by legislation or used imprecise terms (regular, appropriate, sufficient etc.) in cases where values were not provided by legislation. Consequently the listed alarm values are not reflecting a thorough evaluation of critical limits. This emphasises the need for separate analysis, in order to achieve specific alarm values for the HACCP plan.

As in the present study attempts have been made to adapt control points suitable for primary production to the principles of HACCP. But few HACCP-like systems for primary production are able to make a clear separation into critical control points and prerequisite programs. And terms as Points of Attention, Control Points and Critical Management Points (Noordhuizen and Metz, 2005; Borell et al., 2001) are applied to include a somewhat wider definition of points to control beyond the prerequisite programs. This could be related to the lack of prerequisite programmes with clear documentation procedures, needed to be implemented before applying the hazard analysis (Sperber, 2005). It has been suggested that mandatory standards for the systems are used as a prerequisite program (Borell et al., 2001), but this and other necessary programs need to be incorporated into a system, which includes description and documentation procedures (Table 3.4). However the need for including a different set of control points into the HACCP system could also be related to the inherent qualities of animal husbandry systems, as single effective control measures are not always available. Many diseases and behavioural problems are multicausale and consequently no single risk factor is available for the control of the problem. In addition animals are living being showing natural diversity in behaviour and susceptibility to diseases, and their present state depends on earlier experiences and interactions with other animals. Consequently risk factors can be difficult to control.

Table 3.4 Example of the documentation procedure of a Prerequisite program, modified from Jenner et al., (2005)

P1 System Maintenance	
1.1 The feeding system To prevent system failure and reduce risk of food deficiency the feeding system requires regular maintenance. The maintenance includes tightening joints, removing clumps of food or dirt, greasing movable parts not in contact with food.	
MONITORING PROCEDURES	
RESPONSIBILITY	Producer
FREQUENCY	At minimum every second month
RECORD	Maintenance check list (document xx)
Monitoring Task Observe that the maintenance is performed according to procedures. Confirm with a visual inspection of the feeding system. Record inspections with date and initials on the Maintenance check list.	
Corrective action If the standard is not being met, the Producer initiates appropriate corrective actions to achieve and maintain conformance with desired result of the standard. For example, • Initiates repair and/or arranges for outside service to repair item(s). Record corrective actions on “Corrective Action Request”. Record with date and initials.	

An evaluation of the HACCP-like system should include testing the system on a sample of farms. By monitoring the occurrence of any of the problems in farms with implemented HACCP-like systems, it should be investigated whether problems are actually limited to a predefined level (e.g. intestinal parasites) or stopped (e.g. pasteurellosis). If the problems persists then the risk factors, monitoring frequencies, alarm values or corrective actions should be re-evaluated. Testing the HACCP-like system on commercial farms should also include an evaluation of the frequency of alarms. Too frequent alarms would reduce the propensity to act on alarms thereby impairing the system. Consequently if alarm values are reached daily or weekly it is necessary to evaluate whether the alarm value is too low, or whether the Control Point is actually a part of a prerequisite program.

4 General discussion

A welfare assessment system designed as an advisory tool was developed and tested on five farms, and a generic HACCP-like system was developed, as input for farm-specific systems, aimed at quality assurance. Both systems have the potential of improving animal health and welfare in organic egg production, although they need further development to be practical applicable as on-farm management tools. The two management tools have very different approaches to improving animal health and welfare, and subsequently different methods, cost and advantages (Table 4.1). This makes them relevant for different purposes and by different producers and other stakeholders in organic egg production.

Table 4.1 Characteristics of the Welfare Assessment Systems and the HACCP-like system

	Welfare Assessment System	**HACCP-like system**
System	Tactic-strategic decision support	Quality assurance using operational management
Aim	Aimed at providing producers with an overview and status of the production. Enables producer to find points to improve	Aimed at preventing unwanted situations.
Method of action	Motivation	Set of rigid guidelines/control points
Effort (time/labour for producer) and costs	Little effort needed (farm recordings of mortality and veterinary records are already mandatory), but costly advisory service	Considerable effort for implementation. After implementation a considerable documentation procedure.
Advantages	Good tool for advisory purposes	Immediate limitation of welfare problems
	Good tool for strategic decisions	Certification
		Easy to communicate between different employees

A welfare assessment system was developed using the DIAS approach, then implemented and evaluated by producers. And the producers stated that the welfare assessment system was an interesting and thorough tool, providing a good insight into the animals' welfare status. The presentation of the welfare assessment report showed that the goals set by benchmarking motivated for management changes. However by using an annual report, a full production period is completed before the management changes are discussed, and this conflict somewhat with producers' requests for instant advises. Also producers failed to see the need for a welfare assessment unless specific problems appeared; instead they suggested that the welfare assessment system should be included in an integrated production assessment. But still the welfare assessment system provided farm-specific results, enabling a thorough analysis of the production, and consequently provided a good basis for tactic or strategic decisions on farm development.

Similar welfare assessment systems have been developed for dairy, pig and mink production (Rousing, 2003; Bonde, 2003; Møller et al., 2003). And the major problem for practical applicability of all the systems is expenses, due to the time needed for farm visits and report writing (Sørensen et al., in press). In the present project it has been suggested to reduce monitoring frequency, and farm visits are reduced to about 2½-3 hours by faster recording procedures and removal of excess recordings. The process of report writing could also be reduced by using database templates if a sufficient number of welfare assessment systems is applied. As discussed by Sørensen et al. (in press) the use of farmers for recording is another option, however time is still required for typing in and checking data, in addition the validity of data needs to be considered if this approach should be used. Nevertheless the system is costly and would require a specific interest in the farms welfare status by producers in order to be implemented at commercial farms.

There are two possible options for applicability of the welfare assessment system; one is integrating the system into an evaluation of the entire production. The idea of including other factors into the evaluation was suggested by the producers in telephone interviews, and it corresponds with both the holistic idea of the organic principles, and with the consumers' interest in organic products, encompassing other issues than animal welfare, as e.g. the sustainability of the system (McGlone, 2001). By creating an integrated system issues, as environmental impact, worker health and safety, food safety, and productivity could be included and form the basis for an evaluation of the general compliance to the organic ideas. The ethical account suggested by Sørensen et al., (1998) is an example of such a system. Another option for practical applicability of the welfare assessment system is as guidance for producers not complying with organic standards. In Denmark the national certification of organic production includes some minimum welfare standards for plumage condition and mortality, which producers must comply with to keep their certification (Plantedirektoratet, 2002). Consequently producers with problems should be highly motivated to improve their production, and they might benefit from a thorough welfare assessment.

In relation to the consumers' demands for high welfare standards, the welfare status of individual farms is not as easily communicated with the welfare assessment system as with the HACCP system. However if the system is implemented a huge data material regarding different aspects of animal welfare is collected, and the advisory service supplying the welfare assessment report will have ample opportunity to make annual accounts on the general welfare status of the involved producers. However studies have shown that experts and lay persons differ systematic in their evaluation of good animal welfare (Lassen et al., 2006). Consequently it should be taken into consideration that a system partly aimed at satisfying consumer demands, incorporates aspects that are important for consumers.

A generic HACCP-like system was developed using an expert panel analysis for selecting welfare problems, associated risk factors and control points. The generic HACCP should be adapted to specific farms and evaluated in terms of suitability of control points, alarm values and monitoring schemes plus effect on productivity, health and welfare. Once implemented the HACCP system provides a rigid set of guidelines for detailed operational management of the production. Due to the documentation procedure the system is easy to communicate to others and consequently it enhances the maintenance of a steady production when changing staff.

The adaptation of the generic HACCP to specific farming conditions should be performed by an advisor, the producer and a 'HACCP facilitator', to ensure that alarm values are chosen at a level suitable for controlling risk factors while at the same time with a realistic work load for the farmer. Time should be given to implement the system and adjust the alarm values and monitoring frequencies. Subsequently the effect of implementing the system should be analysed by measures of disease incidence and productivity. Measures of productivity is important to include, as the HACCP system also should prevent sub clinical states of diseases influencing productivity, consequently leaving effects measured only by disease incidence underestimated. The effects should be analysed using farms with or without the HACCP system, however as discussed by Verstegen et al. (1995) one must be vigilant in selecting the control farms.

The advantages of HACCP-like systems, aiming to prevent important health and welfare problems by controlling risk factors are obvious. Particularly concerning those problems that are difficult to control after they first appear, or problems with very serious consequences; for instance pasteurellosis, resulting in high mortality rates and long term consequences on egg production, or feather pecking, which can be very difficult to control when first started. But in animal husbandry conditions concerning development of behavioural problems or diseases are not always fully comprehended. And some diseases and behavioural problems are very difficult to control within the farm, due to uncontrollable factors influencing the animals, as rearing conditions and contamination of the outdoor area. This emphasises the need for a thorough documentation of the effect of the system.

In terms of economics, the welfare assessment system is relatively expensive to apply, while HACCP is relatively cheap. However the implementation of the HACCP system requires a considerable effort, and studies have shown that small companies, as most husbandry systems are, have difficulties implementing HACCP (Taylor, 2001). On the other hand, egg packing companies in Denmark (Hedegaard) have already implemented HACCP-like systems at their producers. And this will probably ease the implementation of further programs, as producers are familiar with the terminology and concept. In addition some control points or prerequisite programs might be shared, reducing the number of extra control points and prerequisite programs, when new HACCP-like systems are introduced.

An additional benefit of HACCP is its usefulness as a certification system. In Denmark the National organic brand has a dominant position on the market, and consumers recognise the brand and identify it with high animal welfare standards (Wier, 2004). Also the Animal Protection Agency has a brand signalling high animal welfare (DB, 2006). Consequently using HACCP as a certifying scheme can be included in either of these two brands as a quality assurance for consumers.

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DEVELOPING A WELFARE ASSESSMENT SYSTEM FOR USE IN COMMERCIAL ORGANIC EGG PRODUCTION

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Abstract *Animal Welfare 2003, **12**: 649-653*

A welfare assessment system is being developed for commercial organic egg production based on indicators of behaviour, health, system, and management, which is the general Danish Institute for Agricultural Science (DIAS) concept for assessing animal welfare at farm level. The welfare assessment system works as an advisory tool for farmers, helping them to improve welfare in their flocks. Identification of individual animals in organic egg production is impossible; therefore, management and welfare assessment are based on flock evaluation. Mortality is often a major welfare problem in organic egg production, to some extent caused by inefficient disease detection and control. Health indicators are therefore closely monitored, including variations in live weight, mortality, food and water consumption, and autopsies. Severe outbreaks of feather pecking and cannibalism causing excess mortality are often induced by the presence of stressors. Various stressors, as well as indicators of stress, are therefore included in the welfare indicator protocol. Finally the daily management effort and routines are evaluated on the basis of a management plan prepared by the farmer and a consultant in cooperation, as well as by use of interviews.

Keywords: *animal welfare, decision support, on-farm studies, organic poultry production*

Introduction

Many organic products, including eggs, have increased their share of the market during the last decade, perceived by consumers as being related to better product quality and animal welfare. However, organic egg production has recently been associated in the news with ill thrift, excess mortality, feather pecking and cannibalism, reflecting public critique of current production procedures. A large variation between farms in mortality and feather pecking indicates that management plays an important role for animal welfare in organic egg production. Farmers therefore need a way to assess the current welfare status of their flocks, simultaneously providing them with a tool to address specific welfare problems.

A welfare assessment system aimed to function as a decision support tool for the farmer has been developed at the Danish Institute of Agricultural Sciences (DIAS) (Sørensen *et al* 2001). The concept is based on a continuous evaluation of welfare, via indicators from four information sources: system, management, animal health, and animal behaviour. Indicators are selected by criteria of information value and applicability for on-farm studies (Rousing *et al* 2001). Welfare assessment systems have been developed for dairy cattle, sow herds and mink farms. The purpose of this paper is to present the welfare assessment system for organic egg production that is currently being developed.

Production-specific criteria for organic egg production

In contrast to cattle and pig production, commercial organic egg production is a synchronised, all-in-all-out type of production with flocks of up to 4500 individuals, and a relatively short production period of about a year. Additionally, individuals move unrestricted in the house and pen. These features, which render individual identification impossible, pose certain limitations on the choice of welfare indicators, especially in the categories 'animal health' and 'animal behaviour'. Most of the information must be collected on the basis of flock evaluation: it is impossible to follow egg production or food consumption for individuals, behavioural observations cannot be performed on focal animals, and there can be no follow-up on single individuals with impaired welfare unless they are physically separated from the flock. However, because of the large flock sizes the patterns and causes of mortality can be used as indicators.

Compared to other egg production systems (Table 1), hens in organic systems live in large flocks, they have unrestricted movement and access to an outdoor area, and they are not beak-trimmed. The housing condition increases the risk of feather pecking, infection and rapid spread of diseases, while the prohibition of beak trimming increases the risk of severe cases of cannibalism. These risk factors increase the need for a close follow-up on symptoms of disease and various stressors, which can initiate feather pecking and cannibalism.

In general, assessment procedures involving examination of single individuals must be of short duration in order to be feasible, and the indicator must be highly prevalent within the flock in order to be detected at all.

Table 1 Rules for different egg production systems.

	Cage	Deep litter	Free range	Organic
Average flock size	4	3000–10000	3000–10000	1–4500 (max. 3000 after year 2010)
Space (hens per m^2)	16	9	9	6
Beak trimming	+	+	+	–
Access to outdoor area	–	–	+	+

Source: Anonymous 2000

Health indicators

Because of the unrestricted movement and the access to an outdoor area, hens in organic production have a high risk of exposure to infectious diseases, including parasites (Permin *et al* 2002). The problem is further amplified by restrictions in medical treatment. Behavioural and clinical signs of infection, if any, can be difficult to detect in the first stages of the disease, but several other indicators can point to a problem, such as changes in food and water intake, weight, mortality, egg production and shell quality (Jordan *et al* 2001). Furthermore, infections will typically spread rapidly among the hens, so indicators monitoring the health status of the flock should be followed closely. Farmers record indicators daily, and autopsies are performed on 2–4 hens per month.

Other health problems detrimental to welfare include development of foot pad dermatitis, keel bone deviations, and lesions; hence a clinical examination, which also includes evaluation of plumage condition, is performed according to standardised methods described by Gunnarson *et al* (1995) and Tauson *et al* (1984).

Animal behaviour indicators

Fear is an adaptive response to threatening stimuli, but in production systems where it is not always possible for individuals to react with a proper behaviour to a stimulus, fear can be a powerful stress factor. Additionally, acute fear responses resulting in violent escape or panic can cause pain or injuries (Jones 1996). Consequences of fearfulness can be a reduced immune response, increased levels of aggression, unwillingness to use the outdoor area, and increased tendency to feather-peck. Many standardised tests for underlying fearfulness (ie individuals' tendencies to be more or less frightened) consist of individual test situations which can be rather time-consuming (eg tonic immobility and open field). For on-farm assessments it has therefore been necessary to adjust tests to be performed in the flock, and to evaluate the responses as general flock responses. Three tests are included in the welfare protocol for later comparisons.

Other behavioural indicators include 'level of aggression', since high levels increase the risk of pain and injuries and will stress the flock, and 'feather pecking', which is a serious problem in many flocks. It is painful for the victims, it increases the susceptibility to diseases, and severe cases can escalate into cannibalism. These indicators are sampled simultaneously by behavioural observations in the house. Recordings are made during the production period and once at the site of rearing.

The outdoor area allows the hens to be active in an enriched environment and the indoor animal density to be lowered during the daytime, reducing social stress. Frequently, however, only a fraction of the flock uses the area, and the majority of outdoor birds stay immediately outside the house. The advantage of an outdoor area is thus reduced, and the risk of contaminating the area immediately outside the house increased. Consequently, welfare could be improved by optimising usage of the area. The number and the distribution of hens in the outdoor area are recorded twice per visit; reliability tests on observation methods have shown satisfactory repeatability and inter-observer variability. Supplemented with information on coverage, weather, time of recording, fearfulness and management routines, it might be possible to point to possible restricting factors preventing optimal usage.

Welfare indicators from system descriptions

Organic egg production in Denmark has, by legislation, several minimum system requirements (eg stocking density, access to outdoor area, spatial requirements of resources) covering the housing system. Evaluation of the system therefore might seem redundant; however, within the frames of the law there are several opportunities for divergence. Organic flocks are kept in various types of house: some are isolated, some are not; some have a slatted area, while others have access to the entire floor; the house can be situated in a corner of the outdoor area, or centrally etc. These differences require different management efforts for optimising animal health and welfare, and consequently detailed recording of the system structure is necessary.

The system (litter, slat, nests, sand bath, perches) is measured and access abilities are evaluated. Conditions of ventilation and the outdoor area (cover and drainage) are recorded.

Management

Initially a consultant composes a plan for the management of the flock together with the farmer, and during the production period the farmer notes any deviations from this plan. An interview is conducted halfway through the production period to clarify incorporated procedures regarding daily routines and surveillance procedures. Regular on-farm monitoring of composition and quality of the floor material, and continuous recording of the indoor climate, are included in the protocol.

Evaluation of the welfare assessment system

A welfare indicator protocol has been developed and is presently being tested on 10 flocks on five farms with commercial organic egg production. Trained technicians carry out recordings eight times during the production period. All included indicators can be recorded within one day per flock. Results are presented in a welfare assessment report and discussed with the farmers, thereby acquiring knowledge of the sufficiency of the indicators and frequency of recordings. Comparing the indicators using statistical analyses will reveal indicators with overlapping information value and provide additional means to adjust the indicator protocol.

Discussion

Several methods for assessing poultry health and welfare have been developed; some focus on single indicators or correlations between few indicators (eg Tauson *et al* 1984), and these studies are used as a basis for more integrated approaches, which include a variety of indicators to obtain an overall picture of health, welfare and productivity (eg Odén *et al* 2002; Hörning 2000). Most often the purpose of these integrated approaches is to compare different systems, and this often results in disregarding variation within systems. But such variation does exist, and one of the main causes might be variation in management. There has been very little research on the effect of management on animal health and welfare in free-range egg production systems. On-farm management effort can be a diffuse area to evaluate: records must often be based on interviews with farmers and are consequently very difficult to validate, and special features such as "how soon are slight behavioural changes (as indicators of diseases) noticed by stockman" can be very difficult to quantify. However, difficulty of approach does not excuse lack of effort, and two Dutch studies, Koene (1999) and Bestman (2000), both found significant correlations between stockman experience and degree of feather pecking in organic layers. This implicates the need for assessing management effort in flock evaluation — particularly in this context, where the purpose of the assessment system is to be an advisory tool for farmers to improve welfare in their flocks. However, focusing on management when comparing housing systems would also be beneficial, since different housing systems require different management approaches. The present study includes most of the indicators used in the integrated studies: some have been slightly modified for improved applicability (time and expenses), others have been added, special production characteristics have been accounted for, and management assessment has been included.

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Measuring fearfulness of hens in commercial organic egg production

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Abstract

To evaluate agreement between flock-based fear tests used in welfare assessments of laying hens in commercial organic farms, three tests were applied in 27 flocks of layers. Tests were performed at 35 and 55 weeks of age and were based on the concepts of 'novel object', 'sudden sound' and two different measures of 'approaching human'. In general, agreements between tests were poor. The two measures based on 'approaching human' had the highest agreement, while the agreement between all other flock-based tests were lower. There was low agreement between testing at age 35 and 55 weeks.

In order to evaluate the degree to which the flock-based fear tests reflect individual hens' underlying fearfulness; tonic immobility (TI) tests were also applied on individual hens in eight flocks. There was large individual variation in the duration of tonic immobility, but also significant difference between flocks regarding mean duration of immobilisation. However there was no statistically significant association between TI-tests and flock-based tests. These results emphasise the need for careful consideration of choice of test stimuli for flock-based fear tests, and indicate that the investigated flock-based fear tests do not reflect the individual hens' underlying fearfulness.

Keywords: *animal welfare, fear test, flock evaluation, laying hens, test stimuli, Tonic Immobility Test*

Introduction

High levels of fearfulness and subsequent fearful reactions can have serious welfare implications in husbandry production in terms of prolonged stress, violent escapes and piling of birds; therefore an assessment of fearfulness was included in a welfare assessment system developed for commercial Danish organic egg production. Many tests for poultry have been developed to evaluate hens' fearfulness (Jones 1996). A common feature of most is that they tend to be based on tests of individual animals, as this remains the logical basis for most experimental setups. However in on-farm assessments time, location and economical constraints reduce the options for identifying and handling single individuals and using special test-areas, and, as such, behavioural fear tests based on flock-evaluations were favoured.

Behavioural fear tests can be divided into different categories dependent on the nature of the test eg startle tests, avoidance tests and tonic immobility (TI). Interpretation of tests can be difficult due to differences in stimuli, prior experience of the birds (Jones 1982), the response eliciting situation, and other factors such as strain (Tauson *et al* 1999; Odén *et al* 2002; Maboub *et al* 2004), sex (Jones 1977), age (Hocking *et al* 2001) and housing system (Jones & Faure 1981). Often a distinction is made between stimuli-specific tests, measuring reactions to specific stimuli, and tests reflecting underlying fearfulness, ie the hens' tendency to react fearfully in any given situation. It has been argued that human avoidance tests are stimuli-specific, while novel object and TI-tests on the other hand reflect the hens' underlying fearfulness, and experiments have shown a low correlation between changes in reactions to stimuli-specific tests and tests reflecting underlying fearfulness (as reviewed by Jones 1996 and Hemsworth 2004).

Flock-based fear tests have been used in some studies, predominately measuring the human-animal relationship by avoidance tests (eg Oden *et al* 2002), but also novel object tests have been used to evaluate general fearfulness in small flocks (Hocking *et al* 2001). However it is still unclear how correlated results from different stimuli-specific, flock-based tests are in commercial flocks. It is possible that flocks that are well habituated to the caretaker will also be more robust concerning other (stimuli-specific) tests as they are likely to have more positive experiences with a wider range of stimuli in the presence of the caretaker. It is also unclear how well results from flock-based tests correlate with individual tests of underlying fearfulness. Results from Hocking *et al* (2001) using flock-based, novel object tests together with individual open field and TI-tests in small flocks of brown hybrid layers, showed a degree of correlation between the novel object and TI-tests, but the results were ambiguous.

The purpose of this study is to evaluate flock-based fear tests applicable to welfare assessments of organic laying hens. Fearfulness is recorded using different stimuli likely to be encountered by hens in commercial production systems. To evaluate agreement between different flock-based tests, two scales of an 'approaching human test', a 'sudden sound test' and a 'novel object' are applied. In order to evaluate whether the flock-based tests reflect the individual hens' underlying fearfulness, TI-tests are performed on individual hens in eight selected flocks.

Materials and methods

Twenty-seven flocks, predominately brown hybrids (6 Lohman Brown, 11 Lohman Silver, 2 Isa Brown, 4 Isa Babcock, 3 HyLine Brown and 1 Hellevad White) were tested with three flock-based fear-tests at 35 and 55 weeks of age. Farms were certified organic, following standard regulations with 3,000 hens per flock, a density of 6 hens m^{-2}, and daily access to an outdoor area. Tests were performed in the stable before opening the pop holes.

In eight of the included flocks (7 Lohman Silver, 1 Lohman Brown) individual hens were TI-tested at 35 weeks of age. The TI-tests took place over two consecutive days between 0800 and 1300h. Flock-based tests were conducted on the second day, prior to catching individual birds.

Data was checked for effects of age (flock-based tests) and day (TI-tests), and agreements between flock-based tests were calculated using Cohen's Kappa, weighted to take into account degree of disagreement. The relationship between flock-based tests and TI-tests were analysed using one-way ANOVA with flock as a random effect. Mean TI-durations for the flocks were log-transformed to improve model fit.

Flock-based fear-tests

Approaching-human (two scales)

A technician wearing white clothes walks slowly through the stable at approximately 0.6 m s^{-1} and records the flock's average response to this movement. The average distance to the nearest circle of hens is assessed several times per walk, via the following scale: 1) 0-1 metres; 2) 1-3 m; 3) 3-5 m and 4) 5-10 m. Similarly, the hens' reactions to the technician are gauged as follows: 1) approaching; 2) no reaction/moves slowly; 3) moves faster than technician and 4) panic.

Sudden sound

Sound is produced by knocking twice on a piece of metal. The hens' reaction is recorded on the following scale: 1) approaching; 2) no reaction; 3) moving away and 4) panic.

Novel object

A ring binder is placed on the floor, and the technician observes at a distance of ≤ 2 m. The time to first peck is recorded on the following scale: 1) 1-15; 2) 16-40; 3) 41-120 and 4) >120 s. A time limit of 300 s was set.

TI-tests

TI-tests are performed on 50 hens per flock. Ten hens are captured at a time and quietly held in transport boxes in the ante room. Each hen is immobilised in a cradle, by placing it on the back and holding a hand on the chest and head. This position is maintained for10 s, after which time taken for the hen to get up is measured. A time limit of 1500 s was set. The immobilisation must last a minimum of 5 s to be considered correctly performed, otherwise a new immobilisation is attempted. Visual stimulation can influence the test results (Gallup *et al* 1972), so the cradle is placed in a box to avoid different visual stimulation of the hens depending on farm and test place. Four sensors are built into the cradle and connected to a computer, which registers the hens' movements and immobility-duration. The number of immobilisations is recorded. After testing, each hen is marked with ink on its feet and released into the flock.

Technical problems with one sensor in the immobilisation cradle resulted in missing observations in all flocks. On average 30.9 hens were tested in the eight flocks, ranging from 13 to 46 per flock (SD = 11.7)

Results

The majority of flock-responses were not fearful, but 7-24% of the flocks did react with some degree of fearfulness to the different tests (Table 1).

Agreements were poor between the flock-based tests (k_w = 0.0 - 0.24) (Table 2), while the agreement between the two different measurements of 'approaching human' was slightly higher (k_w = 0.34). Agreements between testing in week 35 and 55 were low (k_w = 0.0-0.41).

Mean TI-times per flock (± SD) for the 8 flocks were 74 ± 122 s, 215 ± 297 s, 336 ± 446 s, 348 ± 283 s, 435 ± 281 s, 459 ± 472 s, 485 ± 377 s and 531 ± 404 s, respectively. There was no systematic difference between TI-tests in day one and two. TI-durations differed significantly between flocks (P = 0.0447; n = 247), but responses to the flock-based tests in these flocks showed little or no variation. All responses to the 'sudden sound' fell within the same category. All 'novel object' tests reached the time limit of 300 s and were terminated. There was complete covariation between the 'approaching human (movement)' and 'distance' scales, however responses all fell within two categories.

Responses to the approaching human tests were not related to TI-results (P = 0.6018).

Discussion

There was moderate agreement between the two scales of the human-approach test, but agreements between the other flock-based tests were poor. This suggests that different stimuli in the tests elicited different responses, which is in accordance with the belief that avoidance tests are stimuli-specific. The large discrepancy between flock-based tests is, nonetheless, noticeable, and since different strains are known to have dissimilar responses, it is possible that the genetic variation in the flocks could have the effect of diversifying reaction patterns thereby blurring the comparisons of the different tests. However, all but one breed were brown hybrids and high similarities between responses from

Table 1 Number of flocks in each response-category (1-4) in the four flock-based fear tests. Each test is conducted in 27 flocks in weeks 35 and 55.

	Category 1		Category 2		Category 3		Category 4	
Test	35	55	35	55	35	55	35	55
Approaching human (distance)	8	7	15	15	4	5	0	0
Approaching human (movement)	0	0	21	20	4	7	2	0
Sudden sound	0	0	26	24	1	3	0	0
Novel object[1]	7	4	2	4	1	3	1	0

[1] 32 flocks reached the time limit and were excluded from the analysis.

Table 2 Weighted kappa-values for the flock-based fear tests (n = 54).

	Sudden sound	Approaching human (distance)	Approaching human (movement)	Agreement between weeks 35/55
Novel Object[1]	0.06	0.01	0.00	0.00
Sudden sound	-	0.10	0.24	0.00
Approaching human (distance)		-	0.34	0.35
Approaching human (movement)				0.41

[1] n = 22, as the time limit was reached in 32 tests.

brown hybrids was found in Odén *et al* (2002). Also, it is noticeable that the two scales of the human-approach tests only had moderate agreement, despite using the same stimuli, which points to careful consideration when selecting scales.

The flock-based tests do not reflect the individual hens' underlying fearfulness, since TI-tested flocks showed almost no variation in the flock-based tests as opposed to large variation in the TI-tests. It is possible that the response categories in the flock tests are not subtle enough to reflect the different levels of individual underlying fearfulness. Also, TI-testing of hens in loose-housed flocks involves catching, handling and isolating individuals which can be serious stressors, thereby influencing the individuals' TI-test results.

Comparing results from flock-based tests at week 35 and 55 showed relatively low agreements. Regular evaluations of the flocks' fearfulness is therefore required in a welfare assessment, if the entire production period is to be evaluated.

An assessment of the flocks' fearfulness is valuable in a welfare assessment, as fearful behaviour can have serious consequences both acutely and longer term. As results are highly dependent on the stimulus, it is important to choose the right stimuli for welfare assessments. Knowing that sudden/unknown sounds and humans are likely to be encountered by the hens during a production period, both the 'sudden sound' and the 'approaching-human' test seem appropriate. Also, the reaction to the caretaker's presence could be included, as inspections and egg collections are daily routines, and fear of the caretaker will therefore be a daily stressor contributing to a reduction in animal welfare. However, the reliability of those tests needs to be assessed first.

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Use of the range area in organic egg production systems: effect of climatic factors, flock size, age and artificial cover

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Abstract 1. To evaluate the effect of climate, flock size, age and artificial cover on the use of range area, a study was conducted in 1994 to 1998, involving 5 farms with a total of 37 flocks of layers kept in commercial, free-range, organic systems. Flocks were visited regularly during the production period to record the number and distribution of hens on the range.

2. On average 9% of the flock used the range area, but with large variations both within and between flocks, and this was partly influenced by climatic factors. Range use was affected by temperature, wind, precipitation, season and age, and there was a tendency for reduced numbers of hens on the range with the time of day and increasing flock size.

3. Eight flocks (including houses and range areas) were divided into 8 paired units, and the range area of one unit in each of the flocks was provided with artificial cover. There were more hens on the range when artificial cover was present and the presence of cover attracted more hens away from the area immediately outside the hen house.

INTRODUCTION

In 1998, when this study was concluded, approximately 10% of Danish egg production came from hens kept in commercial organic production systems (StatBank Denmark, 2003), the average flock size including more than 4000 hens (Danish Poultry Council, 2000). Organic regulations imply among other things access to a range area (minimum $5\,m^2$/hen) covered with grasses or plants (Danish Poultry Council, 1994). Use of the range area is to the benefit of animal welfare, because usage will lower the density of hens in the house during the daytime, increase access to resources and opportunity to perform spatial behaviours, and provide the hens on the range with an enriched environment. But in practice there are often problems, namely, that only a fraction of the flock use the range area and furthermore often with a very skewed distribution across the range, with the majority of hens remaining in the area immediately outside the hen house (Hughes and Dun, 1982; Keeling *et al.*, 1988; Harlander-Matauschek *et al.*, 2001*a*; Zeltner and Hirt, 2003). The skewed distribution has often been discussed in relation to the attractiveness of the range area (for example, Appleby and Hughes, 1991; Grigor, 1993; Bubier and Bradshaw, 1998). For example, many range areas are simply fenced open fields, included in the yearly rotation scheme on the farms. This does not provide the hens with many opportunities to seek shelter from weather or predators, and studies of both hens and chickens have shown positive correlation between the presence of cover and number and dispersion of poultry on the range (Gordon and Forbes, personal communication; Mirabito and Lubac, 2001; Bestman *et al.*, 2002; Zeltner and Hirt, 2003).

A number of other possible restricting factors have been investigated to explain the limited number of hens on the range: number of pop holes (Keeling *et al.*, 1988), availability of cover (Grigor and Hughes, 1993), rearing conditions, fear (Grigor *et al.*, 1995) and genetics (Kjaer *et al.*, 2000). The number of hens on the range also seems to be very dependent on weather conditions (for example, Hughes and Dun, 1983; Keeling *et al.*, 1988). Although the literature on this subject is scarce, the possibility that the behaviour covaries with weather conditions means that recordings, even within flocks, can be very variable and therefore very difficult to use in comparative studies,

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unless weather conditions are standardised or corrected for.

Age is an influential factor in a large range of poultry behaviours: feather pecking, aggression (Odén *et al.*, 2002), rate of activity (Channing *et al.*, 2001), tonic immobility and avoidance of novel objects (Hocking *et al.*, 2001). Observations on chickens have shown increasing use of the range area with increasing familiarity (age) (Mirabito and Lubac, 2001; Kjaer and Mench, 2003) and familiarity is also known to reduce fear of the outside area in layers (Grigor, 1993). Age could therefore be another influential variable concerning the hens' use of the range.

Finally, very few studies on the use of the range area have been carried out on larger (commercial-sized) flocks, although flock size has been shown to significantly influence the average percentage of hens outside (Appleby and Hughes, 1991; Grigor, 1993; Bubier and Bradshaw, 1998; Harlander-Matauschek *et al.*, 2001*b*).

In the present study, 37 flocks on 5 commercial organic farms were observed to determine their use of the range, as influenced by climatic conditions, flock size, age and artificial cover. The first part of the paper deals with the influence of climatic factors, age and flock size on the hens' use of the range area. The second part presents the results of an experimental set-up evaluating the effect of artificial cover.

MATERIALS AND METHODS

From 1994 to 1998 production on 5 commercial farms was recorded in detail (Kristensen, 1998). These farms all complied with the standards of organic egg production of the Danish government. Farms had one to three separate flocks of layers simultaneously. Flocks were housed at approximately 16 weeks of age, used for one laying cycle and slaughtered after approximately one year of egg production. A total of 37 flocks were included in this study (Figure 1), ranging in size from 513 to 6000 individuals/flock (74 000 hens in total). Of the 37 flocks in the study, 34 were ISA Brown and the remaining three were Lohmann Brown. All farmers were asked to give their flocks year-round access to the range area, and record data and conditions in situations when access was restricted.

Experiment 1: climatic factors, age and flock size

Flocks were visited between 6 and 41 times during a production period. Visits were planned to be evenly distributed throughout the year and this succeeded in summer, spring and autumn, as an equal number of visits were made in these seasons. But only 12% of observations (approximately half of those planned) were in wintertime, primarily due to flocks having restricted access to the range area in rough weather. If flocks were restricted then no recordings were made.

Flock size, recording time (time of day and date), and the number and position of hens outside were recorded at each visit together with climatic conditions (temperature, cloud coverage, wind speed, precipitation). All counts were conducted at least 15 min after opening the pop holes in the morning and before 17:00 h. Counts were normally distributed throughout the day, with a maximum around 12:00 h, and 90% of counts were performed between 08:42 and 15:35 h.

Access to the range area followed day-length given that pop holes were generally opened between 08:00 and 10:00 h and closed around dusk. Houses were illuminated by daylight supplemented with artificial light in darker sections of the house and in times of insufficient daylight. All farms followed an individual light programme with a minimum light period of 14 h and a maximum of 16 h. Windows were usually covered up for better control of daylight, so the primary sources of natural light were doors and pop holes opened during the daytime.

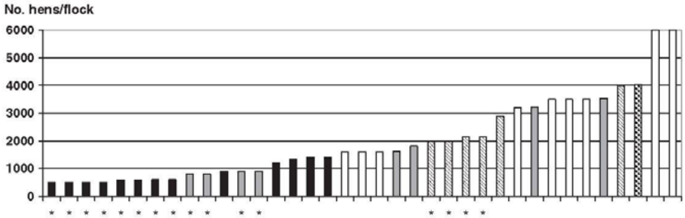

Figure 1. *Initial flock sizes. Each bar represents one flock. Flocks from the same farm have identical shading. Flocks marked with a * participated in an experiment involving artificial cover in the hen run.*

Statistical analysis, experiment 1

A generalised linear model predicting 'number of hens on range' was developed using the GENMOD procedure of the SAS System (SAS Institute, 2001). The response variable was count and a Poisson distribution with a log link was chosen. Log(number of hens in the flock) was used as an offset to account for the different possible outcomes of counts attributable to differences in flock sizes.

The resulting model was: log(number of hens outside) = log(number of hens in the flock) + log(time of day) + temperature + (temperature)^2 + flock size + wind speed + precipitation + season + age + flock. The degree of correlation between observed and predicted average percentage hens outside was high (Spearman Correlation Coefficient, $r = 0{\cdot}86$, $N = 635$).

Risk factors tested in the model building process were: time of day, temperature, age, wind, flock size (small, medium, large), precipitation, cloud coverage, breed, season, flock and farm. The model was developed from a larger model, finding the better fit via log-likelihood or Akaike's Information Criterion (AIC).

Overdispersion was compensated for by estimating the common dispersion parameter via the Pearson statistic, using the scale option in the GENMOD procedure. Before compensating for overdispersion the model was checked for systematic deficiencies as wrong link function, need for transformation of covariates, outlying observations, etc. Finally, correlations between repeated recordings within the same flocks were incorporated into the model via the repeated statement, which uses the Generalised Estimation Equation (GEE) approach (Liang and Zeger, 1986) to account for correlations between clusters of observations. This approach also allows handling of different numbers of observations per unit.

Experiment 2: artificial cover

An investigation was carried out on the effect of providing artificial cover on the use of the range area. Four houses and their adjacent range areas were each divided into two units (marked with * in Figure 1) as identical in shape and size as possible. One of the units in each house was provided with artificial cover and this cover was moved to the other unit once during the production period. In the following production period, the order was reversed. Eight flocks were split into two units in the experiment.

The artificial cover consisted of dome-shaped tents, made of cast iron covered with army camouflage nets, open in the lowest 50 cm on one side allowing hens to enter. The tents measured 2·5 m in diameter and 1·2 m in height and were placed at regular intervals down the pasture, starting 20 m from the pop holes. One tent was provided for every 50 individuals in the flock.

Range areas were divided into rectangles, marked with white sticks in the corners, for recording the location of hens in the range area. These rectangles were categorised as being 'close' to the house, with direct access from the house (comprising on average 7% of the total range area), 'remote' from the house, that is, the rectangles placed farthest from the house (comprising on average 40% of the range area) and finally 'medium' distance, or all rectangles between 'close' and 'remote'.

Statistical analysis, experiment 2

Eight flocks were split into matched pairs and observed in the experiment. Observations in these pairs were almost simultaneous, with differences in weather conditions, time and age assumed to be insignificant. Observations from matched pairs were tested using the GENMOD procedure of the SAS System (SAS Institute, 2001), accounting for repeated measurements within flocks.

RESULTS

A total of 637 observations were made, giving an overall average percentage of hens outside of 9% (Figure 2). However, the numbers both within and between flocks varied greatly, ranging from 0 to 38% between single observations and 2 to 24% on the flock averages.

Experiment 1: climatic factors

Temperature, wind, precipitation, season and age all had a significant effect; there were also tendencies for decreasing use of the range during the day and as flock size increased (Table). 'Cloud coverage' was excluded from the model due to high correlation with other factors, and 'breed' was excluded due to lack of significance. The 'farm' effect was accounted for by the included 'flock' effect, as they are nested variables. The effect of each factor included in the model is illustrated in Figure 3, in which the predicted values of the single factors were calculated assuming that all other factors were set to values that maximised the number of hens outside. This optimal condition is rarely seen and, when changing the values for any one of the factors included in the model, the predicted number of hens outside will be reduced.

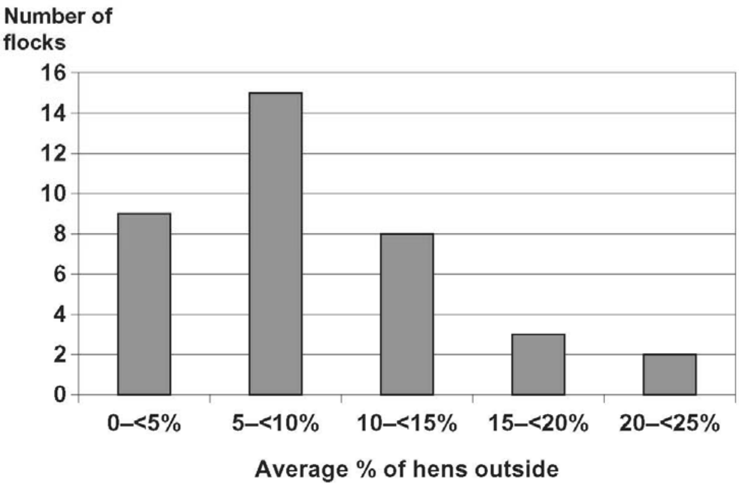

Figure 2. *Number of flocks with 0 to <5%, 5 to <10%, 10 to <15%, 15 to <20%, 20 to <25% of hens recorded outside on average.*

Table. *Results of multivariable analysis of factors influencing layers' willingness to go outside (N = 635, GENMOD procedure, SAS System)*

Variable	Estimate[1]	SE	P^2
Intercept	−1·5735	1·5457	
Log(time of day)	−0·3438	0·2252	0·1532
Temperature	0·0502	0·0110	0·0019
Temperature squared	−0·0015	0·0004	0·0100
Age (months)	−0·0302	0·0096	0·0166
Wind speed			0·0083
No wind (<2 m/s)	0·3027	0·0633	
Leaves move (2 to 3 m/s)	0·3109	0·0992	
Twigs move (4 to 5 m/s)	0·2773	0·0724	
Branches move (6 to 7 m/s)	0·2553	0·0995	
Small trees bend (8 to 10 m/s)	0·0211	0·0684	
Medium trees bend (11 to 13 m/s)	0·1432	0·0966	
Large trees bend (14 to 16 m/s)	0·0707	0·0896	
Storm (>17 m/s)	0		
Flock size			0·1530
Small (0 to 1000 hens)	0·8113	0·2509	
Medium (>1000 to 3000 hens)	0·3742	0·2001	
Large (>3000 hens)	0		
Precipitation			0·0408
Dry	0·8504	0·1366	
Medium–high atm. humidity	0·8970	0·1212	
Drizzle/fog	0·8603	0·1330	
Rain/snow	0		
Season			0·0006
Autumn	0·4917	0·1244	
Spring	−0·3003	0·1069	
Summer	0·1120	0·1188	
Winter	0		
Flock			0·4327
No. 1–37[3]			

[1]Parameter estimates for the log-linear model for the count data. Categories with parameter estimates = 0 are reference categories.
[2]*P*-Values for each factor in the overall GEE Score test.
[3]Flock estimates ranged from −1·7593 to 0·56.

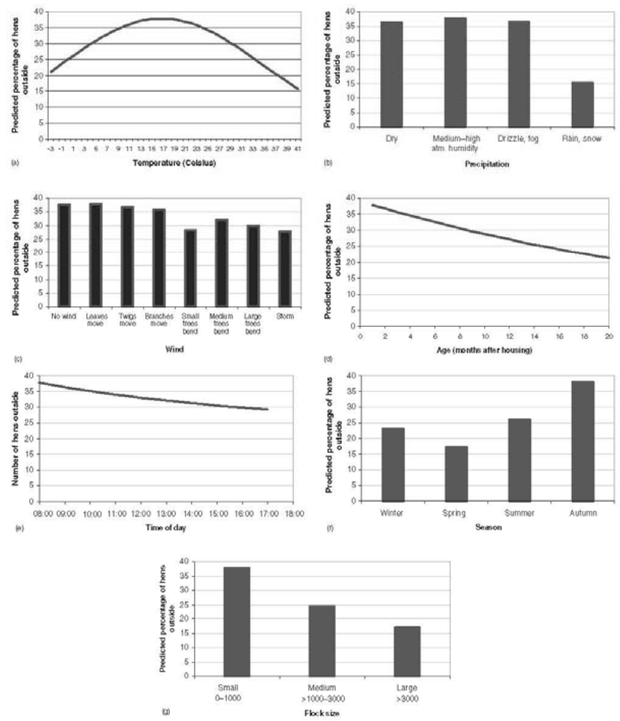

Figure 3. *Predicted effect of factors included in the model (a: temperature, b: precipitation, c: wind speed, d: age, e: time of day, f: season, g: flock size). When predicting the effect of a specific factor, the other factors included in the model are standardised, corresponding to the conditions giving the maximum number of hens outside: temperature = 17°C; precipitation = medium-high atmospheric humidity; wind speed = leaves move; age = one month after housing; time = 09:00 h; season = autumn; flock size = small (0 to 1000).*

Experiment 2: artificial cover

There were significantly more hens outside when artificial cover was present than when no cover was present (11% *vs* 9% of flock size, $N = 151$ paired observations, $P = 0{\cdot}0144$).

The range areas were divided into three sections (close, middle, remote) with respect to the distance from the house, and the majority of hens stayed in the closest and middle sections, while almost no hens were seen in the remote section (Figure 4). The artificial cover had the effect of directing more hens away from the close ($P < 0{\cdot}0001$, $N = 292$) and middle sections ($P = 0{\cdot}038$), however artificial cover did not significantly affect the use of the remote section of the range areas.

DISCUSSION

Climatic factors

In the study, the effects of climatic factors on number of hens on the range have been quantified. The number of hens on the range decreased with increasing wind speed and with precipitation, and showed a parabolic relationship with temperature: the number of hens on the range increased until temperature reached about 17°C, after which the number decreased. The temperature-dependent behaviour can be explained by the discrepancy between the temperature extremes of the unprotected range area and the more temperature-regulated houses. In cold periods, hens are more likely to stay inside,

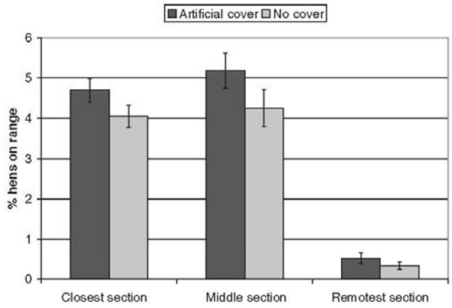

Figure 4. *Percentage of hens in respectively closest, middle and remotest sections of the range area, in flocks with and without artificial cover (mean ± SEM).*

as the houses are warmer than the outside area and the close proximity to other hens will increase the birds' ambient temperature. In contrast the house will provide shadow on hot still summer days, which could be why the hens were more likely to stay inside when the temperature increased above 17°C. There was also a strong seasonal effect with more hens outside in autumn and fewer in spring. This effect is probably partly related to periods of abundance of feed outside and partly to habit, because farmers are more likely to keep the hens indoors in the cold, wet and windy periods often seen in winter and early spring. The last-mentioned explanation is supported by the fact that, according to farmers' records, restriction of access to range areas occurred much more frequently in January and February compared to the rest of the year.

The effects of some climatic factors have previously been noted, as windy and wet weather have been found to have a negative effect on number of birds outside (Gordon and Forbes, personal communication) and more birds are seen outside on dry overcast days compared to dry sunny days (Davison, 1986), corresponding to a combination of the modelled wind, temperature and precipitation effect. But although noted, the effects have not previously been singled out and quantified.

Age

Use of the range area was found to decrease with increasing age, which was somewhat unexpected, as use was expected to increase with familiarity. But while there might have been an initial increase in use of the range area due to increased familiarity in the first one or two months after housing, this effect did not continue throughout the entire production period, which lasted about a year. In the present study recordings are conducted from one month after housing onwards, and the effect of familiarity is therefore not apparent in the results. Other effects of age could explain the decreasing use of the range. For example, several studies have shown plumage condition to worsen with age (Tauson *et al.*, 1984; Huber-Eicher and Sebö, 2001), thereby increasing energy requirements and potential feed consumption (Tauson *et al.*, 1999). This could have the effect of attracting more birds to the house where the food and water supply was situated, and consequently the use of the range area would decrease with age. In contrast to this effect younger birds were found to spend more time feeding and drinking compared to older ones, however, rate of activity was found to decrease with age (Channing *et al.*, 2001) offering an alternative explanation to reduced use of the range area as age increased. Also negative experiences in the range area, as for example continuous predatory attacks as mentioned by Keeling *et al.* (1988) can result in a decreasing use of the range.

Time of day

Usage was found to decrease during the day, which was unexpected, because other studies have found number of hens on the range to peak every evening (Davison, 1986; Bubier and Bradshaw, 1998). However this difference might be explained by different recording times: all recordings within this project were conducted before 17:00 h, and the peak seen in other studies might have been later in the day.

The daily activity of the hens was likely to be influenced by day-length and would therefore be related to the seasonal effect, however, in this study the day-length was to some extent standardised throughout the year by running a light programme and shutting out natural daylight from the houses until the pop holes were opened in the mornings. Also having the majority of observations within the timeframe 08:42 to 15:35 h means that most observations were during the hours of natural daylight, even in December.

Flock size

There appeared to be a tendency for the percentage of hens outside to decrease as flock size increased (Figure 3), although flock size did not significantly affect the use of the range area. A similar tendency was shown in a survey conducted by Grigor (1993) covering flock sizes from 1 to 7000, with what appears to be two cut-off points, one when flocks exceed 500 hens and another when flocks exceed 4000. However, the proportion of the flock seen outside in Grigor's survey averaged 40% in flocks comprising 3000 individuals, which is far more than was found in the present study, and seems to suggest that Grigor's figures were based on recordings conducted solely under optimal age, time and climatic conditions. A clear relationship between flock size and use of the range area was also found in 4 flocks studied by Bubier and Bradshaw (1998), however, more in line with the present findings average use ranged from 42% in a flock of 490 birds to 5% in a flock of 2450 birds. Similar tendencies have been found in recordings of smaller flocks comprising 250, 500 and 1000 birds (Harlander-Matauschek *et al.*, 2001*b*), and also within that range, differences have been discovered between flocks of less than 40 and more than 1000 birds (Appleby and Hughes, 1991).

All of these studies show reduced use with increasing flock size, which is also supported by the same tendency seen in the present model. There does seem to be some disagreement on when flock size becomes limiting. This could be caused by other factors overshadowing the size effect in certain situations, for example, condition of the range area (presence of high vegetation), management effort, rearing conditions, genetic differences, etc. The lack of significance in the present study might also be attributed to relatively few observations with flocks comprising more than 3500 hens.

Flock effect

Obtaining a full picture of the management and accounting for the diverse differences in management practices is one of the major difficulties when observing on private farms; there are usually a number of unexplained differences both between farms and between flocks on a single farm depending on the exact design of indoor and outdoor areas, placement, flock sizes, etc. In the model these differences are accounted for by including a flock effect. Although not statistically significant it improved the model and resulted in parameter estimates ranging from −1·7593 to 0·56, indicating influential effects on number of hens on the range.

Application of the model

Dependent on the age factor, climatic situation and flock size, the percentage of hens on the range can be reduced from 40% under optimal conditions to 15 to 30% by each factor included in the model (Figure 3). This emphasises the need for recording under clearly specified conditions, or correcting data for the different recording conditions, if data are from a survey across flocks. Data can be corrected in several ways. If corrections are not conducted according to a model, for example simply choosing to avoid recordings in strong wind and rain, and collecting data within the same seasonal period as performed by Bubier and Bradshaw (1998), the number of hens on the range will probably be less variable between recordings and the results better suited for comparisons across studies. Likewise attempts should be made to avoid comparing results from very different age groups, seasons, temperature ranges and flock sizes, because these would also give highly variable results.

Artificial cover

In the artificial cover experiment the overall distribution of hens on the range was skewed with very few hens in the remote section. There were almost equal numbers of hens in the close and middle sections of the range, although the close sections constituted only 7% of the range area, while the middle section was far larger (53% of the range area). This is the general picture not only from this study but also from numerous other studies (Hughes and Dun, 1982; Keeling *et al.*, 1988; Grigor, 1993; Harlander-Matauschek *et al.*, 2001*a*; Zeltner and Hirt, 2003). However, results show that the presence of cover had a significant influence on both number and distribution of hens on the range. Although the effect seems rather small, it was statistically significant. Two factors identified in the literature may have reduced the effect in this case: (1) the distance birds needed to travel to reach the cover (Mirabito and Lubac, 2001; Bestman *et al.*, 2002) and the construction of the cover, because there is more initial attraction to two-dimensional cover compared to three-dimensional cover, possibly because three-dimensional cover reduces the ability to scan for aerial predators (Grigor, 1993). It is therefore highly possible that changing the position and using different kinds of cover would give more pronounced effects.

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animal

Developing a HACCP-like system for improving animal health and welfare in organic egg production – based on an expert panel analysis

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In the process of developing a generic Hazard Analysis and Critical Control Point (HACCP)-like system for securing animal health and welfare in organic egg production, an expert panel analysis was used to perform the initial hazard analysis. Eighteen advisers and researchers in organic egg production were included in the expert panel. In a series of four questionnaires, the expert panel first scored 34 health and welfare problems seen in Danish organic egg production. Based on scorings of severity and occurrence, 10 problems were selected for further analysis. The experts subsequently suggested and scored risk factors for those problems and finally suggested control points, alarm values indicating the need for corrective actions in order to control the risk factors and monitoring frequencies of these. The 10 selected problems were hunger, thirst, piling, crop impaction, blackhead, pasteurellosis, bone fractures, cannibalism, predators and red mites. A total of 154 different risk factors were suggested for these problems. The 41 risk factors which rated highest in a combined scoring of importance and occurrence were selected for further analysis. There was a high degree of consensus between experts when scoring both problems and risk factors. The level of consensus, as defined by an interquartile range ≤1, was 79% to 100% when scoring the health and welfare problems (scale 1–5) and 77% to 95% when scoring the risk factors (scale 1–4). On average, 5.8 control points were suggested for every risk factor. Alarm values were often not detailed enough to be of practical significance and further analysis is needed in order to define these. The experts were highly diverse in their suggested monitoring frequencies and establishment of monitoring schemes should be part of developing the farm specific systems. An expert panel analysis based on questionnaires was a useful tool during the first steps of developing a HACCP plan, conducting a hazard analysis and suggesting control points. However, care should be taken regarding the panel's size and fields of expertise in order to assure that the panel fully covers the field of interest throughout the study. A further development of the hazard analysis into a farm-specific HACCP system would include assembling an on-farm HACCP team consisting of farmers and advisors for the practical application of control points, alarm values and monitoring schemes. The results from the fourth questionnaire would be useful as input for this work.

Keywords: expert panel, HACCP, welfare

Introduction

Organic egg production is struggling with problems compromising the health and welfare of the animals, as indicated by high rates of mortality (Hermansen *et al.*, 2004) and high levels of feather pecking (Bestman and Maurer, 2006). The organic consumers as well as the organic organisations emphasise the importance of good animal welfare (Harper and Makatouni, 2002; International Federation of Organic Agriculture Movements, 2006). The fact that some farms have serious problems while others seem to work fine suggests that management is an area which can be improved (Hegelund *et al.*, 2006).

The Hazard Analysis and Critical Control Point (HACCP) system is a management tool developed to secure food safety. During the last decade, the HACCP concept has gained general acceptance in the food processing industry and is presently implemented by several authorities in among others like the EU, the USA, Canada and Australia (Ropkins and Beck, 2000). HACCP systems are based on

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prevention, by controlling the risk factors for any given (food) hazard. The HACCP system consists of seven principles. The first three principles include (1) defining the problem (the hazard) and defining and evaluating risk factors for the problem, (2) defining critical control points and (3) choosing alarm values for the critical control points. The succeeding principles are integration of the critical control points in a HACCP system, which includes (4) setting up schemes to monitor critical control points and establishing (5) corrective actions if alarm values are exceeded, (6) verification procedures to ensure that all procedures are performed according to plans and (7) documentation procedures for keeping records of all procedures (Food and Agriculture Organization, 2001). HACCP systems can be extensive and time consuming to produce (Baird *et al.*, 2001), making construction of generic systems within specified production types desirable for many small-scale production facilities (Food Safety and Inspection Service (FSIS), 1997). Generic systems serve as guidelines for subsequent further development of a HACCP system tailored for a specific production facility (FSIS, 1997; Canadian Food Inspection Agency, 2005).

As a consequence of the wide application of HACCP systems, interest has arisen to adapt the HACCP system to the livestock production, also focusing on key issues other than securing food safety (Noordhuizen and Frankena, 1999). The advantage of using a system based on prevention rather than cure seems obvious when dealing with animal health and welfare. HACCP-like systems have recently been developed with the purpose of securing animal welfare and managing diseases, as for instance pre-slaughter stress in pigs (Von Borell and Schäffer, 2005), calf-rearing management (Boersema, 2006), quality assurance on dairy farms (Silva *et al.*, 2006) and herd health management in organic pig production (Bonde and Sørensen, 2004). However, using the HACCP system to secure animal health and welfare poses different challenges than applying HACCP for food safety purposes. In the food industry, the risk factors (i.e. disease causing agents) are clearly defined physical entities (bacteria, metal pieces, etc.) which can be traced through the production chain. In contrast, risk factors for the development of welfare problems often comprise specific housing conditions or animal interactions which cannot be treated as yes/no entities. This leads to a central point of the HACCP development: defining and evaluating risk factors for the chosen problem. Often the lack of empirical knowledge of the importance of each risk factor reduces the possibility completely to control the problem within the frames of the farming system (Noordhuizen and Frankena, 1999). This is especially true for multicausal problems such as tail biting in pigs or cannibalism in poultry. Expert panel analyses can be used to analyse situations where empirical data are too scarce to perform traditional statistical analyses (Vose, 2000).

The purpose of this paper is to describe and discuss the development of a generic HACCP-like system, aimed at securing animal health and welfare in commercial organic egg production. The HACCP-like system is developed on the basis of an expert panel analysis.

Methods

Experts familiar with organic egg production systems were used to perform the first steps of an HACCP analysis, including defining the health and welfare problems, defining and evaluating risk factors for the problem, defining critical control points and choosing alarm values for the critical control points. The experts filled out a series of four questionnaires, where the design of each questionnaire was dependent on the answers of the previous questionnaire. The method has many similarities with a Delphi approach, which is frequently used in the human health-care sector (e.g. Keeney *et al.*, 2001) but which has also been applied within animal husbandry and management, for a quantification of expert knowledge (Van der Fels-Klerx *et al.*, 2000; Sørensen *et al.*, 2002).

Although Delphi analyses are widely used, there are no standard definitions for consensus (Powell, 2003). In the present study, the level of consensus is measured using the interquartile range (IQR), with the following definitions: $IQR =< 0.5$: strong consensus, $0.5 < IQR <= 1$: moderate consensus, $IQR > 1$: no consensus.

Recruitment

As a result of the expert panel, analysis is an aggregation of the experts' assessment of a given problem, where the choice of experts becomes highly important. To ensure that experts had the same field of expertise and the same cultural and legislative background, experts were included on the basis of two criteria. (1) Experts should be researchers and/or advisors with experience in on-farm welfare in commercial free-range or organic egg production systems. (2) Experts should be from EU countries geographically close to Denmark. To avoid bias, only one expert could be included per research institute. The aim was to include 15–20 experts in the panel. All correspondence was performed via e-mail and the experts were anonymous to each other.

Six key persons in Denmark, Sweden, Germany, The Netherlands and The UK were selected. The key persons suggested candidates for the expert panel and, in addition, the contacted panel candidates were asked to suggest other relevant candidates.

Questionnaire sequence

As explained below, the process of the expert panel analysis was a repeated sequence of preparing a questionnaire (Q), sending it to the expert panel, collecting replies and preparing the next questionnaire based on these replies.

Questionnaire 1 (Q1). A list aimed to include the health and welfare problems seen in Danish organic egg production was assembled. Initially, the list included the primary causes of death seen in Danish organic egg production and behavioural deprivations caused by inability to perform natural behaviours (Johansen, 2003). Subsequently, four Danish researchers with experience in practical management and two poultry advisors from the Danish Agricultural Advisory Service were asked to add suggestions and comment on the list. This resulted in a list of 34 health and welfare problems seen in Danish organic egg production (Appendix A).

In Q1, the experts were asked to score each of the 34 problems according to how severe is it for the animal's welfare to be subjected to the problem ('severity') and how often an animal in the organic egg production is subjected to the problem ('frequency'). Severity and frequency were scored on a five-point scale: 5 = very severe/very frequent, 4 = severe/frequent, 3 = moderate/regular, 2 = less severe/rare, 1 = not severe/very rare.

Questionnaire 2 (Q2). The median values of severity and frequency were calculated for each problem and based on these scorings, the most important health and welfare problems were selected. The most severe (scoring 5) and most frequent (scoring 5) problems were selected first and then the most severe (scoring 5) and less frequent (from 4.5 to 1) problems were selected. To reduce the scope of the expert panel analysis, a maximum of 10 health and welfare problems were set to be the limit for the subsequent analysis.

In Q2, all experts received a spreadsheet with the selected health and welfare problems listed in the same chronological order and were asked to suggest risk factors for these problems.

Questionnaire 3 (Q3). Based on the replies to Q2, lists of risk factors for each problem were generated. The lists were edited with the purpose of ensuring that all risk factors were equally detailed. Risk factors with a high degree of similarity were merged and risk factors not compatible with organic regulations were deleted, e.g. beak trimming is prohibited according to organic regulations, so 'no beak trimming' is not accepted as a risk factor for 'cannibalism'.

To check for problems with response-fatigue when filling out the comprehensive spreadsheet, the number of suggested risk factor per problem was examined.

In Q3, experts were asked to score each risk factor with respect to how severe the risk factor is for developing the welfare problem (severity) and how frequent the risk factor occurs in the production (frequency). Severity and frequency were scored on a four-point scale: 4 = severe/frequent, 3 = moderate/regular, 2 = less severe/rare, 1 = not severe/very rare.

Questionnaire 4 (Q4). After the panel had rated the risk factors, the median values of severity and frequency were calculated and risk factors were chosen based on their scorings. The aim was to include an average of 3–4 risk factors per problem, but imposing the criterion that all hazards have a minimum of one risk factor. Risk factors with the following scorings were selected: severity 4 and frequency 2–4; severity 3.5 and frequency 3–4; severity 3 and frequency 4.

In Q4, the experts were asked to list all possible control points in as much detail as possible for each risk factor and also suggest alarm values for each control point. Control points were defined as 'elements of the production that needed to be monitored (controlled) in order to prevent the risk factor from appearing', and alarm values as 'the values that separate good conditions from bad conditions'. Examples were given to the experts in order to clarify the explanation. For example, the risk factor for intestinal parasites 'insufficient cleaning of the outdoor area near the house, between flocks' could have the following control point and alarm values: change of top soil between flock: change of top 10 cm of earth in 0–15 m distance from pop holes.

Results

Recruitment

Thirty-two experts were contacted, and 18 accepted participation in the expert panel. They were from Denmark (4), Germany (3), the UK (3), Sweden (2), The Netherlands (2), Austria (1), Norway (1), Finland (1) and Switzerland (1). One expert was included after preparation of Q2, and therefore only participated in Q2 to Q4. While in one case, two experts cooperated in answering; they returned only one set of questionnaires and were registered as only one expert in the panel.

Questionnaires were prepared and sent out in May (Q1), June (Q2), July (Q3) and September (Q4) 2005. As the expert panel analysis progressed, the response rate dropped from 17 in the first two questionnaires to 12 in the third and 13 in the final questionnaire. Reminders were sent to experts not complying with the deadlines and the number of reminders increased from 3 in Q1, to 5 in Q2, 7 in Q3 and reached 19 in Q4. In Q4, six experts responded without reminders, four responded after the first reminder, and three responded after two reminders.

Questionnaire 1

Ten problems were selected for further analysis: hunger, thirst, piling, crop impaction, blackhead, pasteurellosis, bone fractures, cannibalism, predators and red mites (Table 1). Seventeen problems scored 4 in severity and 2 to 3 in frequency, and the remaining seven problems scored 2 to 3 in severity and 2 to 5 in frequency.

Consensus was reached in all selected problems when scoring severity (20% strong and 80% moderate) and in eight of the selected problems when scoring frequency (20% strong and 60% moderate). Among the 24 problems that were excluded, there was consensus in 21 problems

Table 1 *Scorings of severity and frequency of the 10 selected health and welfare problems*

	Severity			Frequency		
	n	Median	IQR	*n*	Median	IQR
Health/welfare problem						
Predators	17	5	1	17	3	1
Cannibalism	17	5	0	17	3	1
Piling	17	5	1	17	2	0
Bone fractures	17	5	1	17	2	2
Crop impaction	15	5	1	14	2	0.8
Blackhead	14	5	1	15	2	0.5
Pasteurellosis	15	5	1	16	2	1
Hunger	17	5	1	17	1	1
Thirst	17	5	0	17	1	1
Red mites	16	4	1	16	4	1.3

n = number of experts scoring the problem; median = median scoring; IQR = interquartile range.

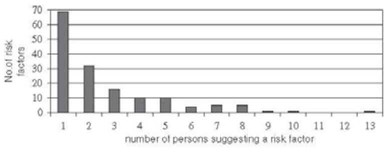

Figure 1 Distribution of number of risk factors suggested by between one and 13 experts in the panel.

when scoring severity (12.5% strong and 75% moderate) and in 19 when scoring frequency (20.8% strong and 58.3% moderate).

Questionnaire 2

Q2 resulted in a total of 412 suggested risk factors including several doublets. After editing, the list of risk factors was reduced to 154 distributed on the following 10 health and welfare problems: predators (9), pasteurellosis (18), piling (13), hunger (20), blackhead (16), crop impaction (12), cannibalism (21), bone fractures (12), thirst (16), and red mites (17). On average, each risk factor was suggested 2.6 times. Sixty-nine of the 154 risk factors were suggested by one expert only (Figure 1).

Apparently, there were no problems with response-fatigue as the health and welfare problems getting the fewest suggestions from the experts were numbers four and six in the spreadsheet, while the first and ninth got the most suggestions.

Questionnaire 3

The list of 154 risk factors was scored by the expert panel and 41 risk factors fell within the selection criteria (Table 2): predators (3), pasteurellosis (3), piling (3), hunger (4), blackhead (2), crop impaction (1), cannibalism (8), bone fractures (4), thirst (7) and red mites (6). Seven of the selected 41 risk factors were suggested by only one expert in Q2.

There was consensus in 119 of the 154 risk factors when scoring severity (28.6% strong and 48.7% moderate) and in 137 when scoring frequency (34.4% strong and 54.5% moderate). Among the 41 selected risk factors, consensus was reached in 39 when scoring severity (39% strong and 56.1% moderate) and in 37 when scoring frequency (29.3% strong and 61% moderate).

Questionnaire 4

Thirteen experts returned the questionnaire and the average response rate for the 41 risk factors was 86.9 (Table 3). A total of 390 suggestions referred to control points, resulting in 99 different suggestions when eliminating doublets (within and between risk factors) and control points not practically applicable by the producers in general management procedures. On average, 5.8 different control points were suggested for every risk factor. Alarm values were suggested in 381 of the answers and, of these, 44.6% were specific enough to be practically applicable. The remaining alarm values were less precise, including terms such as 'high' or 'good'. A monitoring frequency was suggested in 260 answers and 88.1% of these were detailed enough to be of practical significance, while the remaining answers included terms such as 'frequent' or 'regular'.

A wide range of control points were suggested, relating to different aspects of the production including caretaker routines/training (15), rearing conditions (7), behaviour (14), production (4), system (27), pasture (6), diet (11), diseases (7) and cleaning procedures (8), as exemplified in Table 4. The large number of control points reflects that some risk factors can be monitored using different types of control points, including both animal-based indicators and system-based indicators. For example, the risk factor for thirst 'animals too small to reach drinkers' can be controlled by checking either drinker height (at level with bird's back) or bird's posture when drinking (stretching neck). In this case, the exact choice of control points should be selected to suit the management in the best possible way when developing the farm-specific systems. Also, some risk factors must be monitored using information from more than one control point, for instance, the risk factor for cannibalism 'physiological stress at onset of lay' would require monitoring of 'bird weight', 'egg production', 'feed plan' and 'light programme'. Other risk factors were easier to monitor, resulting in uniform suggestions from the panel, e.g. the risk factor for predators: 'insufficient closure of pop holes', where all experts agreed on 'check closure of pop holes every evening'.

In some cases, a considerable variation was seen in the suggested alarm values for the same control point. It was most pronounced in the suggested alarm values for control point 'stocking density' in order to avoid 'piling' which were 4, 5 and 6 hens/m^2. However, most differences were seen in monitoring frequencies, e.g. in the control point 'checking

Table 2 *Selected risk factors based on scorings in questionnaire 3*

		Severity			Frequency		
	Risk factor	*n*	Median	IQR	*n*	Median	IQR
Hazard							
Predators	Insufficient closing of pop holes at night	12	4	1	12	2	1.3
	Security of house/holes in the house	11	4	0.5	11	2	1.5
	Poor fencing	12	4	1	12	3	0.5
Pasteurellosis	No disease identification when mortality rises	8	4	0.3	8	2.5	1
	No vaccination of 'high risk' flocks	7	4	1	6	2	0.8
	Poor clean out between flocks	8	4	1	8	2.5	1
Piling	High stocking density	12	3.5	1	11	3	1
	Nervousness/fearful hens	12	4	1	12	2	0.6
	Rearing: insufficient habituation to stressors	12	4	1	12	3	0
Hunger	Malfunctioning feeder system	12	4	1	12	2	0
	Electricity failure	12	4	1	12	2	1
	Pathology (e.g. crop distension)	11	4	0.5	11	2	1
	Illness/injury preventing movement/eating	12	4	0	12	2	1.3
Blackhead	Poor pasture management	10	3.5	1	10	3	0
	Poor clean out between flocks	9	4	1	9	2	1
Crop impaction	Feed deficiency	11	4	1.5	11	2	1
Cannibalism	Poor diet	12	4	1	12	2.25	1
	No elevated perches/no adequate use	11	4	2	11	2	1
	Low stimulation	12	4	0.3	12	3	1
	No action at first signs of cannibalism	12	4	0	12	2.25	1
	Occurrence of wounds	12	4	0	12	2	0.6
	Feather pecking	12	4	1	12	3	0.3
	Poor management of pullets in rearing	12	3.5	1	12	3	1
	Physiological stress at onset of lay	12	4	1	12	3	0
Bone fractures	Poor/rough handling during catching	11	4	0.5	11	3	1
	Rough handling during production period	11	4	0.5	11	2	0.5
	Poor diet	11	4	0.5	11	2	0.5
	Equipment broken or with sharp edges	11	4	1	11	2	0
Thirst	Not enough drinkers	12	4	1	12	2	1
	Malfunctioning water system (pipes, drinkers)	12	4	0	11	2	0
	Insufficient supply (e.g. pressure, electricity)	12	4	0.3	12	2	1
	Thermal stress	12	4	0.3	12	2	1.3
	Poor accessibility of water (design)	12	4	1	12	2	1
	Animals too small to reach drinkers	12	4	0.3	12	2	1
	Illness/injury preventing movement/drinking	12	4	1	12	2	1
Red mites	High temperatures	11	4	1	11	3	1
	Poor house and furniture design	11	4	0	11	3	0
	Insufficient cleaning/disinfection between flocks	11	4	0	11	3	1
	Poor hygiene during the production period	11	4	1	11	3	1
	Delayed treatment if number of mites rises	11	4	1	11	3	0
	Underestimation of consequences if number of mites rises	11	4	1	11	3	1

n = number of experts scoring the risk factor; median = median scorings; IQR = interquartile range of scorings.

the house for holes' to avoid access of 'predators', suggested monitoring frequency included 'daily, 'weekly', 'every 6 months' and 'every year'.

Discussion

The health and welfare problems used as a starting point for the questionnaire series correspond quite well to the health problems seen in European organic egg production, as reviewed by Thamsborg *et al.* (2004) and Bestman (2004), and problems associated with performing natural behaviour as described by Waiblinger *et al.* (2004); however, some differences are noticeable. Some diseases included in the reviews were not included in Q1 and although the agreement between the two reviews is limited to only five diseases, one of those, *coccidiosis*, is not included in Q1. *Coccidiosis* was omitted because it is consistently controlled by vaccines and is predominately considered a problem in the rearing units (Johansen, 2003), while the present system is developed for egg production. In addition, feather pecking was excluded from the list

Table 3 *Response rate and number of specific answers from the experts in the panel, in questionnaire 4*

	Total	Average	Minimum	Maximum	s.d.
Total number of suggestions in Q4	462	11.3	7	13	1.7
No. of suggestions including control points	390	9.5	1	13	2.6
No. of different control points					
• Not excluding doublets between risk factors	237	5.8	1	14	3.3
• Excluding doublets within and between risk factors	99				
No. of suggestions including monitoring frequencies	260	6.3	1	13	2.6
• No. of specific monitoring frequencies	229	5.6	1	13	2.6
No. of suggestions including alarm values	381	9.3	1	13	2.6
• No. of precise alarm values	170	4.1	0	8	2.1

Table 4 *Examples of problems with associated risk factors and control points*

Problem	Risk factor	Control point
Bone fractures	Poor/rough handling	Carry hens on both legs
Cannibalism	Poor management of pullets in rearing	Visit at rearer
Thirst	Not enough drinkers	Aggression by drinkers
Cannibalism	Physiological stress at onset of lay	Start of egg production
Hunger	Malfunctioning feeding system	Feeding line running
Pasteurellosis	No disease identification	Daily/weekly mortality

although it is probably one of the most used indicators of welfare problems in organic egg production (e.g. Bestman and Maurer, 2006). This decision was taken because feather pecking, sometimes being a precursor of cannibalism (Kjaer, 1999; Thamsborg *et al.*, 2004), would be controlled as part of preventing cannibalism. On the other hand, 12 health and welfare problems not mentioned as health or welfare problems in the reviews were included in the questionnaire. Three of these (hunger, thirst and crop impaction) were subsequently selected for further analysis. In conclusion, the risk of missing problems such as thirst, which is related to impaired system maintenance and therefore unlikely to gain attention in research papers, and the lack of empirical evidence on the severity of the problems, emphasises the value of an expert panel for scoring and thereby selecting problems for further analysis instead of basing the selection solely on literature reviews.

Analysis of the responses indicates that the expert panel might be undersized. Seventeen percent of the selected risk factors in Q3 were suggested by only one expert in Q2. This appears to be a relatively low degree of overlap between experts and a possible consequence is an increased risk of missing important risk factors. The problem is most obvious in the third and fourth questionnaire where the response rate dropped to 30%. A considerable drop in response rate is not unusual in studies comprising a series of questionnaires (Mullen, 2003). It is probably caused by the long duration of the analyses and the anonymity of the experts, as they consequently feel less motivated or obligated. Studies show that a very close follow-up on responses can improve the response rate (Keeney *et al.*, 2006). Consequently, including more experts in the panel may have resulted in a more comprehensive analysis of the problem areas and compensated for missing expertise due to falling response rates.

Due to the considerable scope of the topic 'health and welfare in organic egg production', the experts need to cover many different subjects which increases the risk of lacking knowledge in certain areas. However, throughout the questionnaire there is generally a high level of consensus between the experts both regarding scorings of problems and scorings of risk factors. The high level of consensus indicates that the choice of experts meets the requirements set for the expert panel and sufficiently fulfils the first part of the analysis. The experts base their knowledge on comparable organic systems and they focus on the same risk factors for controlling health and welfare parameters in productions. Still, there is a tendency for the total percentage of consensus (including strong and moderate) to be lower when scoring severity in Q3 compared with Q1, indicating more disagreement when scoring risk factors; especially, when considering that changing the scale from Q1 to Q3 increases the chance of a higher level of consensus in Q3.

In the fourth questionnaire, the experts suggested many different control points. Some of this variation is caused by the multicausal nature of the health and welfare problems, resulting in a need for multiple control points when managing the problems. But also the experts' preferences for system-based *v.* animal-based indicators would result in different control points. The experts were also diverse in their suggested alarm values, but whether this apparent diversity would lead to low consensus is not investigated in a rating questionnaire. The most obvious problem was the lack of specific alarm values to some of the control points. A general reluctance to set alarm values probably reflects the fact that many control points in the production have a continuous range of values, ranging from 'perfect condition' to 'unacceptable', and setting a specific value separating 'good' from 'bad' is very difficult. Consequently, the stated alarm values do not reflect a thorough evaluation of critical limits, emphasising the need for a separate analysis to achieve specific alarm values for the HACCP system. It is unlikely that simply rephrasing the questions would result in more specific answers, as all experts were able to supply specific alarm values to some of the control points. Still, the suggested control points and alarm values can be used as input for developing the farm-specific HACCP systems.

The combination of lack of practical management experience by the experts and the lack of information of the specific housing conditions probably made it difficult for the expert panel to agree on monitoring frequencies. Consequently, the specification of monitoring frequencies should be a part of developing the farm-specific systems.

In conclusion, using an expert analysis to develop a generic HACCP system has led to selection of important problems and risk factors. In addition, a number of possible control points with related alarm values and monitoring schemes were suggested. A further development of the hazard analysis into a farm-specific HACCP system would include assembling an on-farm HACCP team consisting of farmers and advisors for the practical application of control points, alarm values and monitoring schemes. Attention should be focused on the selected risk factors and the results from the fourth questionnaire can be used as input for selecting appropriate control points. The alarm values should ensure that the value targeted as the appropriate level of each risk factor is not underestimated, however, a separate analysis is necessary to define this level.

Acknowledgement

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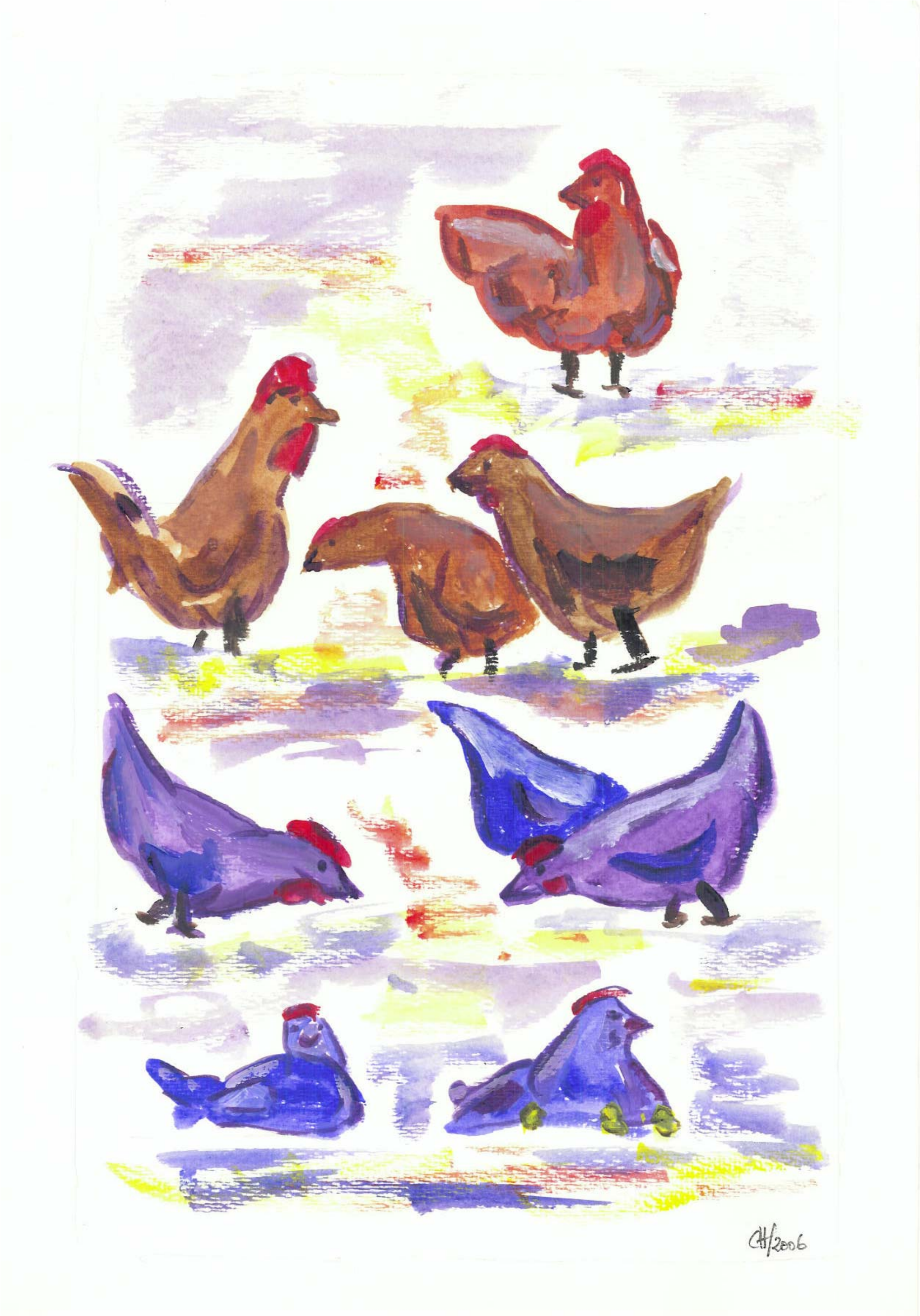
Appendix A

Health and welfare problems in commercial Danish organic egg production
The 10 selected health and welfare problems are indicated by bold letters

Infectious bronchitis
Erysipelas (inf. with *E. rhusiopathiae*)
Fowl colera (pastaurellosis)
Escherechia coli infection
Salpingitis
Blackhead (Histomoniasis)
Bone fractures
Foot pad dermatitis
Red mites (*Dermanyssus gallinae*)
Intestinal nematodes (e.g. *Ascaridia galli*)
Crop impaction
Hunger
Thirst
Negative energy balance
Malnutrition
Heat stress
Cold (frost)
Inappropriate light
Dust
Ammonia
Predator attacks
Cannibalism/vent pecking
Piling of birds resulting in suffocations
Inactivity (no stimulation)
Fearfulness
Aggression
Inability to perform natural behaviours:

- foraging behaviours
- mother/chicken interactions
- sexual behaviours
- nesting behaviours
- comfort behaviours
- explorative behaviours
- hide/escape from aggressions
- hierarchical interactions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Appendix 1

The initial welfare indicator protocol, with a description of recording methods. Suggestions for improvements are based on evaluation of indicators from tests, presentation and discussion with producer and subsequent interviews.

Table 1 Initial welfare indicator protocol, initial recording method, and suggestions for improvements, based on evaluation of indicators from tests, presentation and discussion with producer and subsequent interviews.

	Initial welfare indicator protocol	**Scores/recording**	**Suggestion for improvements**
System and management			
	Resources (nests, perches, water, feeding line, pop holes):	Illustrate accessibility of resources, by drawing a sketch of house.	Sketch, not suitable for comparisons. Instead estimate average distance and max distance to resources.
		Capacity of resources	Ok
	Range area	Range area: draw sketch noting, size and bushes/trees. Divide range area into 4-6 sections with increasing distance to stable, for an evaluation of hens' distribution. Division is performed by marking corners.	Sketch not suitable for comparisons. The division of the range should be reduced to only three sections, and sections distance from stable should be specified in advance, e.g. close:0-15 m medium: 15-50 distant: >50 in order to improve comparisons between farms
	Quality of range area (own scoring system)	vegetation in range area (% of each section, as defined above): low: - vegetation height 0–20 cm high: vegetation height 20–100 cm bushes: bushes (appr. height 100–180 cm) trees: trees (appr. height 180 cm –>)	Should include a category allowing for other types of structure (eg. straw bales)
	Quality of range area (scoring system adopted by Sillebak (1997))	The most dominant types of vegetation are noted in each section	Too extensive data-material not usable, not able to interpret relevance for welfare.
	Litter condition (own scoring system)	litter moisture (percent): 1: wet, 2: very moist, 3: little moist, 4: dry litter structure (percent): 1: crusted, 2: clots, mostly manure, 3: clots, mostly straw, 4: loose litter quality (percent material in the top layer): 1: manure,	ok, but improve presentation

		2: straw, 3: sand 4: other	
	Management plan developed in cooperation between farmer and advisor.	Deviations from management plan noted. Incidence of diseases noted.	irregular notes
	Vaccination schemes from breeder		Ok
	Interview	Amount, type and place of dispersion of roughage, hygiene routines, use of hired staff, salmonella status	ok, but improve presentation of roughage. Should include details on feed spread in litter Should include information on outdoor cleaning procedure between flocks
Behaviour			
	Use of range area	Number of hens in each section of the range area. Note temperature (in shadow), wind speed, precipitation.	ok, presented as distribution in range area. Percentage outside is not a stable measure. It should be substituted with information on quality of range area and signs of wear of vegetation.
	Aggressive pecks (as Kjær 2000)	Number of pecks by feeding line, when starting running (length 2 meters, both sides). Number of pecks by nests, before noon (length 3 meter of platform). During 2 x 2 minutes. Spend 5 minutes in stable before observing to avoid disturbance. Note number of birds in area	not reported due recording errors. Should probably be substituted with clinical examination of wounds in combination with information of resource accessibility and capacity.
	Tests of fear response (movement: as Odén et al., 2002; distance: own scoring system)	*Approaching human, distance to test person* *1:* 0-1 m 2: 1-3 m 3: 3-5 m 4: 5-10 m. *Approaching human, movement in relation to test person* 1: approaches/no reaction 2: moves slowly 3: moves fast 4: panic	Indication of stimuli specific responses. Select stimuli with care. Unknown person, caretaker, sudden sound – could all be important stimuli. However methods need to be tested for reliability.
		Sudden sound 1: approaches 2: no reaction 3: moves away 4: panic	
	(recorded on a continuous scale, subsequent categorisation: own scale)	*Novel object (sec to first peck)*: 1: 0-5 sek. 2: 5-15 sek. 3: 15-40 sek.	

		4: >40 sek.	
	floor eggs	recorded daily by producer	Ok
Health			
	Plumage condition (as Tauson et al, 1984)	Scoring on body parts: neck, back, breast, wings, tale 1: Severe damage, mostly naked skin 2: damage of feathers, lack of feathers. 3: Light damage, possibly few lacking feathers 4: Light wear, no other damage.	ok, presented both as total body score and scoring of single body parts
	Wounds - 5 body parts, feet, comb (modified from Gunnarson et al., 1995)	3: no damage 2: few wounds: <= 5 pecks/scars 1: severe damage: > 5 pecks/scars, bloody wounds.	feet: not in presented in reports due to low prevalence. Others ok
	Feet, abscesses (as Kjaer, 2000)	1: Several large abscesses 2: One large or several smaller 3: One smaller abscess or a healed wound. 4: No signs of damage	ok, however results only presented as normal feet >< impaired feet health, so possible change of scale. Improve presentation
	Keel bone (as Gunnarson et al., 1995)	4. Normal 3. Slightly deform, < ½ cm. 2. Deform, ½ - 1 cm. 1. Deform, > 1 cm.	not in presented reports due to low prevalence
	Mortality	recorded daily by producers. Cause of death noted in the following categories: piling, predators, other	ok, presented both as survival curve and percent dead caused by …..
	Red mites (own scale)	1: 0 2: 1-10 3: 11-20 4: 21-50 5: 50-100 6: >100.	Insufficient filling of traps by producers. Difficult to quantify numbers of mites - records not in accordance to producers experiences. Change method: visual inspections of nests and perches. Or reliability tests of different mite traps <u>and</u> better instruction of producers.
	weight	recorded during clinical examination	ok, presented both as weight curve and weight spread.
	Egg production, number	recorded daily by producer	ok, especially when food and water consumption is lacking
	water consumption	recorded daily by producer	Producers not able to separate water consumption from other use. Not able to include.
	food consumption	recorded daily by producer	Producers not able to separate daily food consumption. Not able to include
	Autopsies	Producers collect the last four dead hens before farm visits. Hens are sent to analysis, for examination of	Producers very interested in results. Not appropriate for on-farm application:

		cause of death, signs of crop impaction and internal parasites.	Substitute method: (1) Signs of crop distension in live birds. (2) Improve interview on outdoor cleaning between flocks, and procedures regarding pasture management: removal of top layer yes/no, frequency of change of pastures.

should be considered included	
	egg shell quality
	Light

Appendix 2

Example of a welfare assessment report. The numbers 472-1, 472-2 and 472-3 refers to the three flocks in farm termed 472. All farms were kept anonymous to each others.

Welfare assessment report for flocks 472-1, 472-2 and 472-3

Indholdsfortegnelse

1. Baggrund og formål med rapporten

En af grundideerne i den økologiske fødevareproduktion er princippet om god dyrevelfærd for husdyrene, og det er et område, der er kommet stadig mere fokus på i de senere år. Dyrenes velfærd afhænger dog i høj grad af sammenspillet mellem dyr, system og den daglige pasning, og der forventes derfor en stor variation i dyrenes velfærd fra bedrift til bedrift.

Husdyrenes velfærd kan betragtes som et produktionsmål på linie med produktivitet, produktkvalitet og bedriftens miljøpåvirkning, og det er derfor nødvendigt for ægproducenten at have en metode til vurdering af hønernes velfærd på flokniveau. En velfærdsvurdering skal beskrive velfærden i flokken i hele produktionsperioden vha. en række forskellige registreringer.

De data, der indsamles til brug i en velfærdsvurdering, skal give information om:

- Staldsystem (type og indretning)
- Systemanvendelse (brug af systemet samt dyrenes pasning og pleje)
- Husdyrenes adfærd
- Sygdomsforekomst

Udviklingen af en metode til vurdering af velfærden i økologiske ægproduktionssystemer sker i forskningsprojektet "Økologisk fjerkræproduktion – udvikling af nye miljørigtige systemer og styringsmetoder til forbedring af dyrevelfærd og fødevaresikkerhed" ved Afd. for Jordbrugsproduktion og Miljø og Afd. for Husdyrsundhed og Velfærd, DJF. Der er indsamlet data fra fem økologiske ægproducenter i én produktionsperiode 2002/2003. Bedrifterne er besøgt en gang om måneden til hønsenes 28. uge, og herefter hver anden måned indtil udsætning. Under besøgene er der foretaget kliniske og adfærdsmæssige undersøgelser, og døde høns blev sendt til obduktion. Der kan mangle enkelte observationer, pga. udbrud af Newcastle Disease i Danmark i sommeren 2002. På grund af smittefaren blev besøg hos besætningerne forbudt i perioden 23/7 - 20/8 2002, hvorefter besøgene først kunne genoptages, efter aftale med producenterne.

I denne rapport er data fra alle medvirkende bedrifter samlet, men opgjort således at resultaterne fra den aktuelle bedrift fremhæves i skemaer og grafer og benyttes som udgangspunkt i kommentarerne. Den samlede velfærdsvurdering er opgjort i starten af rapporten, og efterfølgende er hovedområderne: sundhedstilstand og dødelighed, system og management samt adfærd nærmere beskrevet, med begrundelse for inkludering i velfærdsvurderingen, opgørelse af resultater samt kommentering af resultaterne fra den enkelte bedrift.

Denne del af forskningsprojektet gennemføres af: Lene Hegelund, Jan Tind Sørensen, Klaus Horsted og John Hermansen.
Registreringerne på de fem gårde er foretaget af forsøgsteknikerne: Michael Steen Hansen, Kristine Riis Hansen, Orla Nielsen samt Henrik Andersen.

2. Sammendrag og konklusion for hele produktionsperioden

Som det fremgår af tabel 1 er der indsamlet data fra fem ægproducenter, der hver har haft mellem et og tre hold. Hver ægproducent er blevet tildelt et nummer, der fastholdes i hele rapporten (182, 462, 472, 502, 872), og de enkelte hold betegnes som driftsgren 1, 2 eller 3.
Der benyttes fem forskellige afstamninger, heraf fire brune og en hvid. Ni ud af ti driftsgrene har den maksimale tilladte flokstørrelse, og kun to driftsgrene (182-1 og 872-1) indsættes i vinterperioden, mens resten indsættes sent forår/tidlig sommer.

Tabel 1 – Basisoplysninger om alle driftsgrene.

Driftsgr.	Afstamning	Antal indsat*	Udruget dato	Alder v. indsættelse	Alder v. udsættelse
182-1	Hellevad, Hvid	3114	13-09-2001	18 uger	80-82 uger
462-1	Babcock	4500	14-12-2001	17 uger	64 uger
462-2	Babcock	4500	14-12-2001	17 uger	64 uger
472-1	**Hyline, Brun**	**3500**	**14-12-2001**	**17 uger**	**69 uger**
472-2	**Hyline, Brun**	**3100**	**14-12-2001**	**17 uger**	**69 uger**
472-3	**Hyline, Brun**	**1400 + 9**	**14-12-2001**	**17 uger**	**69 uger**
502-1	Lohman, Brun	4500	17-01-2002	16 uger	66 uger
502-2	Lohman, Brun	3000	17-01-2002	16 uger	66 uger
872-1	Isa Brown	3000	15-10-2001	16 uger	60-61 uger
872-2[a]	Isa Brown	3000	06-02-2002	16 uger	52-53 uger

* tal angivet efter '+' er antal indsatte haner.

[a] i leveuge 45 blev der indsat 1500 høner fra driftsgren 872-1. Dele af holdet er derfor ældre ved udsættelsen.

Denne velfærdsvurdering tager udgangspunkt i 3 flokke fra samme gård: driftsgren 472-1, 472-2 og 472-3. Alle hønnikerne er fra samme opdræt og indsat samtidig.

Driftsgren 472-1

Som driftsgren 472-1 er der indsat 3500 Hyline-brun hønniker, udruget den 14/12-01. Huset er symmetrisk indrettet med redekasser i midten omgivet af gødningskummer med slats, hvor der er foder og vand. Adgang til udearealet er via udgangshuller til veranda, placeret ved endegavl. Foder, rede og vand er således jævnt fordelt og lettilgængeligt for hele flokken, mens adgangen til udearealet er mere begrænset.
Udearealet består af en forgård med træer i den bagerste del, hvorfra der er en passage til et indhegnet skov/krat-område. Bagerste hegn ligger 234 meter fra huset.

Driftsgren 472-2

Som driftsgren 472-2 er der indsat 3100 Hyline-brun hønniker, udruget den 14/12-01. Huset er indrettet med et areal, hvor der er redekasser omgivet af gødningskummer med slats og vand. Gulvarealet strækker sig fra området nedenfor gødningskummerne til to skrabearealer placeret ved den ene endevæg samt den ene langside. Der er adgang til udearealet, samt en veranda, fra de to sidstnævnte skrabearealer. Foderbåndet er placeret på slats samt gulvarealerne nedenfor gødningskummerne samt det ene skrabeareal. Foderbåndet er lettilgængeligt i store dele af huset, mens redekasser og vandnipler er samlet på et areal der udgør mindre end halvdelen af huset. Der er begrænset adgang til udearealet fra den bagerste del af huset.
Udearealet består af en forgård med bevoksning i den ene side. I forlængelse af forgården ligger et indhegnet markstykke, med spredte halmballer. Bagerste hegn ligger 330 meter fra huset.

Driftsgren 472-3

Som driftsgren 472-3 er der indsat 1400 Hyline-brun hønniker, udruget den 14/12-01. Huset er indrettet med redekasser omgivet af gødningskummer med slats og vand og foder. Gulvarealet strækker sig fra området nedenfor gødningskummerne til et skrabeareal placeret ved den ene endevæg, hvorigennem foderbåndet også løber. Foder, rede og vand er lettilgængelig fra hele huset, mens adgangen til udearealet er begrænset fra den bagerste del af huset.
Udearealet er et næsten kvadratisk stykke skov, med ca. 75 meter til bagerste hegn.

Sammendrag

Den samlede dødelighed for driftsgren 472-1, 472-2 og 472-3 er relativt høj, ca. 24%, men heraf mangler ca. halvdelen ved slutafregningen. Denne resterende del udgøres af høner, der er taget af rovdyr eller på anden vis forsvundet fra produktionen. Andelen af døde pga. klumpning ligger på 5,2-5,6% af flokken, og hos driftsgren 472-1 og 472-2 ligger størstedelen af disse klumpninger i starten af produktionsperioden. Flere af klumpningerne i driftsgren 472-3 har derimod ligget i vinterperioden, dvs. relativt sent i produktionsperioden.

Vægtudviklingen bør følge normkurven for afstamningen. Fald i gennemsnitsvægten, lavere tilvækst end forventet eller høj spredning kan skyldes foderproblemer, sygdom eller stress. Vægtudviklingen hos driftsgren 472-1 og 472-2 følger stort set normkurven, bortset fra et fald i slutningen af produktionsperioden. Hos driftsgren 472-1 og 472-2 var ensartetheden i hønernes vægt under 80% omkring leveuge 28 og 60, hvilket er sammenfaldende med fund af *pastaurella*, samt udbrud af kannibalisme. Hos driftsgren 472-3 var der knæk på vægtkurven omkring leveuge 28, 44 og 60, og dette følges af lav ensartethed i leveuge 28 og 44.

Strøelsens beskaffenhed har en indflydelse på udvikling af fodbylder, sygdomsudviklingen, mulighederne for god fjerpleje, aktivering mv., og der har i perioder været problemer med fugt, skorpedannelse samt et højt indhold af gødning i strøelsens øverste lag, især i driftsgren 472-2 og 472-3. I driftsgren 472-2 stiger mængden af gødning kraftigt i perioden oktober-januar, og der ses problemer med fugt og skorpedannelse. Driftsgren 472-3 har især problemer med skorpedannelse i juni, og i sidste del af produktionsperioden kan ingen dele af gulvarealet karakteriseres som helt løst og tørt. Der er sand til støvbadning i hele produktionsperioden i alle driftsgrene, dog med en tendens til, at sandet erstattes af gødning, jo ældre hønerne bliver.

Der har ifølge producenten været stor belastning af blodmider i sommerperioden. Registreringerne har vist mange blodmider i driftsgren 472-1 og 472-3, men kun et begrænset antal i driftsgren 472-2.

På trods af perioder med strøelsesproblemer er der slet ikke registreret fodbylder i nogen af driftsgrenene, men her kan en god brug af udearealet aflaste stalden og aktivere hønerne, til fordel for fodhelsen.

Generelt er der en meget høj udnyttelse af udearealet i alle tre driftsgrene, og især i driftsgren 472-2 er der en stor spredning af hønsene, således at området umiddelbart udenfor huset belastes mindst muligt. Det skal dog bemærkes, at arealet af område-kategorierne ikke er ens.

I driftsgren 472-1 og 472-2 udvikles fjerpilning, og der konstateres udbrud af både kannibalisme og *pastaurella*, hvilket tyder på en stress-påvirkning af flokken. Mange forskellige faktorer kan stresse hønsene, dels har der været nogle mindre driftsforstyrrelser, f.eks. afsmag i foder (leveuge 25 og 28), frossent vand i udestuen (472-2 og 472-3: leveuge 55), problem med foderanlæg (472-3: leveuge 59), men også mange skiftende afløsere kan være medvirkende. Det skal dog bemærkes, at managementstrategien på denne bedrift indbefatter, at de daglige rutiner gøres så simple som mulige for at hindre stress hos hønsene i tilfælde af, at rutinerne må ændres eller udelades. Begrænset adgang til ressourcer kan også medføre stress samt øget aggressivitet, og stald samt inventar er generelt underdimensioneret i driftsgren 472-1 og 472-2. Der kan derfor være en sammenhæng til antallet af skader på kam, der er over gennemsnittet, og adfærdstestene, der tyder på en højere grad af frygtsomhed.

Driftsgren 472-3 skiller sig meget ud fra de andre driftsgrene i denne undersøgelse, idet tegnene på stress og aggressivitet er langt mindre i denne flok. Dels er der ingen fjerpilning, ingen obduktions-resultater, der tyder på pastaurella, færre frygtsomme reaktioner i adfærdstestene og gennemsnitligt færre sår på kammen. Dette på trods af de ovennævnt driftsforstyrrelser samt underdimensioneringen af staldarealet samt foderstrengen. Systemmæssigt adskiller driftsgren 472-3 sig især fra de andre driftsgrene ved en langt mindre flokstørrelse, samt adgang til et helt skovbevokset udeareal.

3. Sundhedstilstand og dødelighed

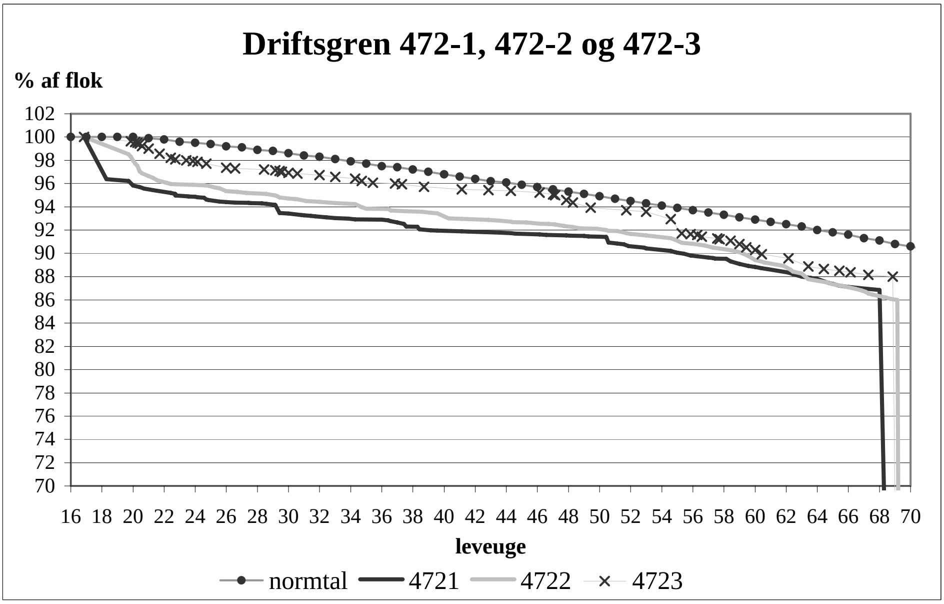
3.1 Dødelighed

Dødeligheden samt dødsårsagerne er vigtige velfærdsindikatorer, der bl.a. kan bruges i en løbende kontrol af holdet. En pludselig stigning i antallet af døde kan skyldes sygdom, der nødvendigvis må søges begrænset hurtigst muligt. Men også en efterfølgende opgørelse over dødelighed kan afsløre, om der f.eks. er høje tab grundet rovdyr, hvilket kan stresse hønsene og evt. betyde, at udearealet findes mindre attraktivt for hønsene. Jævnlige obduktioner kan medvirke til at afklare, om der kan være velfærdsproblemer i form af indvoldsorme eller om bestemte sygdomsmønstre/dødsårsager er dominerende i en flok.

I normtallene fra Landskontoret (fig. 1) kalkuleres med en samlet dødelighed på 9 % for brune æglæggere, hvis produktionen fortsætter til 68. leveuge. Avlsfirmaerne rapporterer om lidt mindre dødelighed: Isa Brown, Babcock: 7 %, Hy-Line Brown: 4 %. Dog oplyses ikke hvilket produktionsforhold disse tal er opnået fra. Det er derfor forventeligt med en dødelighed på knapt 10%, inklusive et mindre tab til rovdyr.

Antallet af døde og solgte opgøres løbende i produktionsperioden (fig. 1). Ved den endelige slagteriafregning bliver det derved tydeliggjort, hvor stor en andel af flokken, der er forsvundet fra produktionen (jf. tabel 2). Størstedelen af denne rest må formodes at skyldes tab pga. rovdyr, men det er også muligt, at de manglende høner er forsvundet i strøelsen (spist af de andre) eller kommet udenfor huset/indhegningen.

Figur 1 – Procent dødelighed, illustreret i form af en overlevelseskurve for driftsgren 472-1, 472-2 og 472-3 sammenlignet med normtallene fra E-kontrollen



I alle tre driftsgrene er dødeligheden større end forventet udfra normtal (jf. figur 1). Fælles for dem er dog, at de efter en høj dødelighed umiddelbart efter indsættelsen stabiliseres, for derefter at have en *dødelighed, der er sammenlignelig med normtallene. Den høje dødelighed umiddelbart efter indsættelsen af driftsgren 472-1 skyldes en klumpning, hvor 127 høns dør. I driftsgren 472-3 er der et problem med klumpning sidst i perioden. Forekomsten af klumpninger i denne driftsgren er bemærkelsesværdig, idet 10 ud ad 16 tilfælde ligger indenfor 3 måneder i vinterperioden (jf. afsnit 6.7).*

I obduktionerne af driftsgren 472-1 og 472-2 konstateres listeria i starten af produktionsperioden og pastaurella i leveuge 43, 52 og 59. Tillige ses der tegn på kannibalisme i de sidste to obduktioner (jf. appendiks 2 og appendiks 3).

Den endelige opgørelse viste en dødelighed på ca. 24% i alle tre driftsgrene, heraf er ca. halvdelen forsvundet fra produktionen uden registrering, dvs. de er spist af rovdyr eller forsvundet i strøelsen.

Driftsgrenene følger et anbefalet vaccinationsprogram, og revaccineres i leveuge 16 (Cor2), 30 (4/91), 40 (Ma5), 50 (4/91) og 60 (Ma5).

Tabel 2 - Registrerede dødsårsager. Døde i procent af antal indsatte hønniker. Rest er andel høner, der ikke er registreret som døde eller solgte og derfor har manglet i flokken ved slagteriafregningen

Driftsgren	**182-1**	**462-1**	**462-2**	**472-1**	**472-2**	**472-3**	**502-1[a]**	**502-2[a]**	**872-1**	**872-2[c]**
antal indsat	3114	4500	4500	**3500**	**3100**	**1400**	4500	3000	3020	4520
antal solgte	2847	3821	3945	**2656[b]**	**2353[b]**	**1063[b]**	?	?	2490	3810
regstr. døde	208	687	560	**465**	**432**	**171**	1260	920	249	547
rest	59	-8	-5	**379**	**315**	**166**			281	163
	Registrerede dødsårsager (antal døde i % af antal indsatte)									
klumpn., %	3,1	7,9	4,9	**5,3**	**5,2**	**5,6**	0,2	2,3	6,2	7,1
rovdyr, %	-	-	-	**2,0**	**0,7**	**1,0**	13,9	14,2	-	-
andet, %	3,6	7,4	7,5	**6,0**	**8,1**	**5,6**	14	14,7	2,1	5,0
rest, %	1,9	0	0	**10,8**	**10,1**	**11,9**			9,3	3,6
døde i alt, %	8,6	15,3	12,4	**24,1**	**24,1**	**24,1**	28,1	30,8	17,5	15,7

a holdene blev ved uheld blandet, og er derfor i nogle tilfælde afrapporteret samlet
b fra slagteriet er der afregnet samlet for de tre hold. 'Antal solgte' er derfor opdelt i andele, der svarer til antal indsatte.
c der blev opr. indsat 3020 høner i hold 872-2, men i holdets 45. leveuge blev der yderligere indsat 1500.

I obduktionsrapporterne er fund af '- renkultur' i leveren en klar indikation på en infektion, mens fund af blandingskulturer kan stamme fra overførsler under obduktionen.

Tabel 3 - Obduktionsresultater. 'I alt' angiver antal udførte obduktioner. Under 'Obduktionsresultater' angives procent fund med diagnosen 'Infektion' (bakterielle infektioner herunder betændelse i bughinde, æggeleder, hjerte, lever samt læggenød) 'Forstoppelse', 'Kloak-hak' (inkl. kannibalisme) samt 'Andet', der er fund der ikke falder ind under førnævnte kategorier. Under 'Bakteriologi angives procent fund af hhv. *'Pastaurella'* og '*E.coli*' i renkultur i lever. 'Spolorm' angiver procent fund, hvor der er påvist spolorm.

		Obduktionsresultater (i %)				Bakteriologi (i %)		Spolorm (i %)
Dgr.	**I alt**	**Infektion**	**Forstoppelse**	**Kloak-hak**	**Andet**	***Pastaurella***	***E.coli***	
182-1	4	0	25	0	75	0	0	0
462-1	18	44	39	11	17	0	67	39
462-2	13	54	23	15	31	0	31	31
472-1	**11**	**73***	**27**	**18**	**9**	**18**	**27**	**0**
472-2	**13**	**46**	**8**	**23**	**31**	**15**	**15**	**8**
472-3	**7**	**14**	**0**	**14**	**86**	**0**	**14**	**0**
502-1	6	100	0	50	0	0	83	0
502-2	5	40	0	20	40	0	40	0
872-1	-	-	-	-	-	0	-	-
872-2	4	25	0	25	50	0	25	75

* Heraf en høne med et stiksår i brystmuskulatur, der har medført betændelse.

3.2 Ægproduktion

Udbrud af sygdom vil ofte kunne ses på ægproduktionskurven, og tilsvarende er det vigtigt at være opmærksom på æggenes kvalitet, da stigning i antal knækæg/vindæg mv. eller forandringer i skal-struktur også ofte er tegn på sygdom. Den daglige ægproduktion samt antal af frasorterede æg er derfor inkluderet i rapporten.
Ligeledes kan tilstedeværelsen af gulvæg give et velfærdsproblem i flokken, idet høner, der lægger deres æg udenfor rederne, er mere udsatte for hak mod kloakken, når slimhinderne synliggøres under æglægningen.

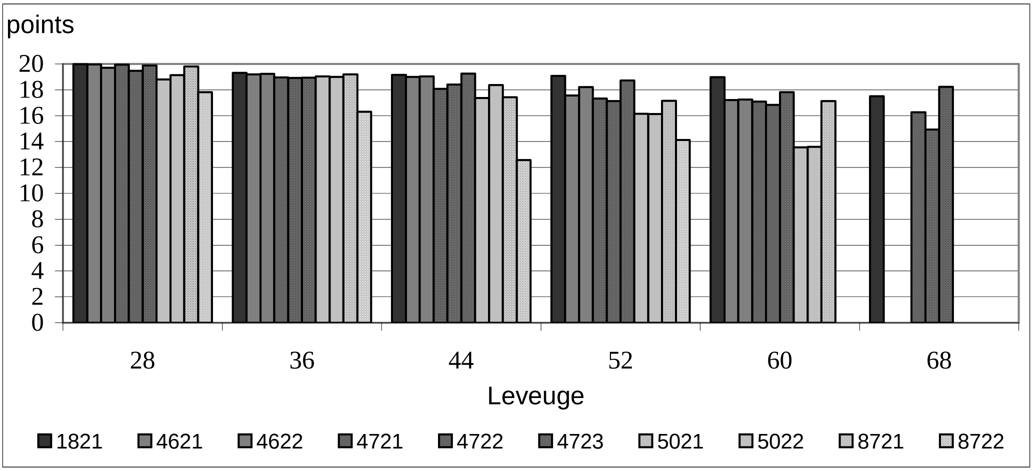
Der er kun få registreringer omkring ægproduktionen fra driftsgren 472-1, 472-2 og 472-3, og de kommenteres derfor ikke yderligere.

3.3 Fjerdragt

Der er foretaget en fjerdragtsbedømmelse på 50 høner/flok i hønsenes leveuge 20, 24, 28, 36, 44, 52, 60 og 68. Formålet med denne bedømmelse er at vurdere, om der har været problemer med fjerpilning i produktionen. Fjerpilning er smertefuld for hønsene, og påvirker derfor direkte deres velfærd. Kraftig fjerpilning kan desuden udvikle sig til kannibalisme. Årsagerne til fjerpilning kan være mange, så tilstedeværelsen af fjerpilning i flokken siger intet om kilden til problemet.

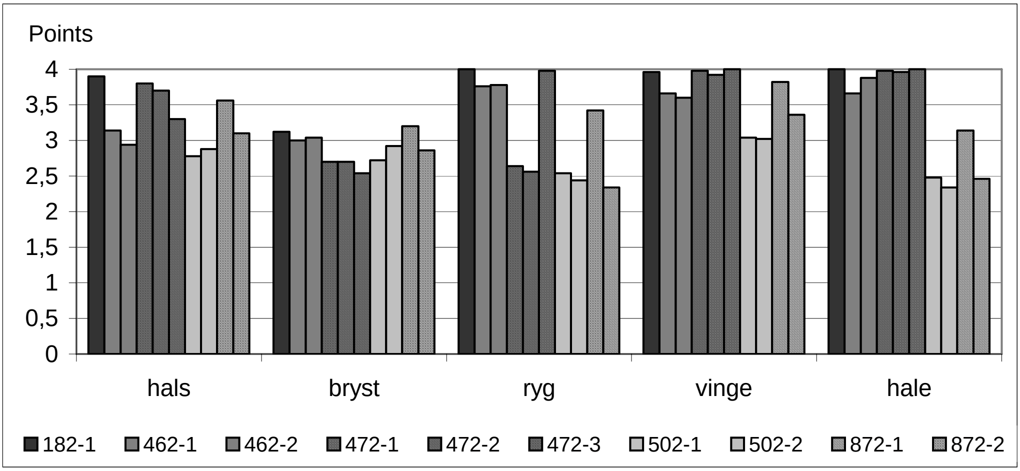
Tab af fjer kan dog også skyldes slid, sygdom, generel stress eller fejlernæring. Der ses ofte en generel forringelse af fjerdragten med alderen, eftersom fjerene slides mod materialer i stalden. Dette slid kan også være problematisk – afhængigt af omfang og årstid - idet områder med bar hud gør hønerne mere følsomme overfor kuldepåvirkninger. Derved kan f.eks. manglende fjerdragt på mave/bug øge modtageligheden overfor bughindebetændelser.

Figur 2 – Udviklingen af hønsenes fjerdragt. Hver søjle er et gennemsnit af fjerdragtsbedømmelsen lavet på 50 høner. I bedømmelsen vurderes hals, bryst, ryg, vinger og hale efter en skala fra 1-4, hvor 4 er den bedste karakter. Den samlede karakter på høner ligger derfor på 5-20 points. Bedømmelserne fra leveuge 20 og 24 er ikke medtaget, da disse alle ligger på eller meget nær 20 points.



Nedenstående figur illustrerer på hvilke områder af kroppen fjerene mistes. Fjerpilning starter typisk på den nederste del af ryggen, og breder sig op af ryggen, ud på hals og vinger samt til halen. Udpræget fjermangel på enkelte dele af kroppen, f.eks. hals eller bryst kan også skyldes slitage mod inventaret.

Figur 3 – Fjerdragtsbedømmelse i leveuge 60 (52 hos driftsgren 872-2). Den gennemsnitlige karakter på fjerdragten fordelt på hhv. hals, bryst, ryg, vinge og hale.

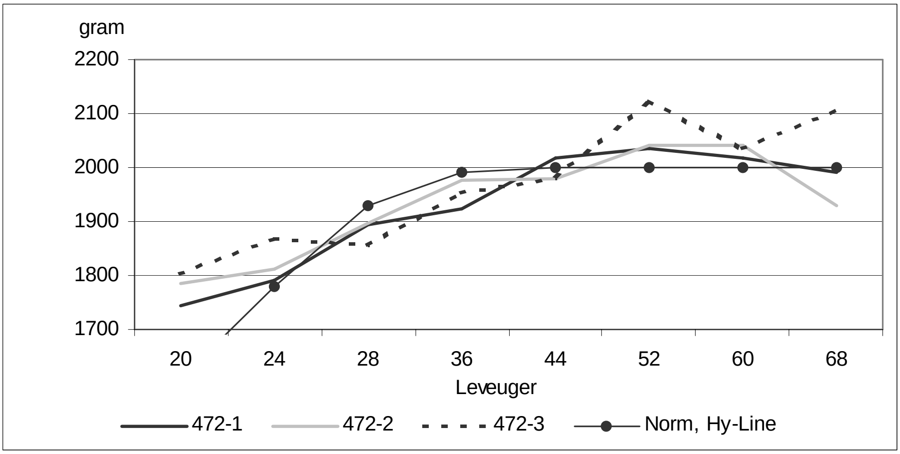


Driftsgren 472-1, 472-2 og 472-3 har samlet set en pæn fjerdragt i hele perioden (jf. figur 2). Driftsgren 472-3 skiller sig lidt ud fra de andre ved en generelt bedre bedømmelse. Dette bliver tydeliggjort ved bedømmelsen af de enkelte kropsdele i uge 60, hvor driftsgren 472-1 og 472-2 får en relativt lav score på ryggen, mens 472-3 her har en stort set intakt fjerdragt (jf. figur 3). Der er således tegn på fjerpilning hos de to førstnævnte driftsgrene, dog med en begrænset udbredelse, da der endnu ikke ses større beskadigelser på hale, vinger og hals.

3.4 Vægt

Det er væsentligt at følge vægtudviklingen hos et hold. Dels kan fald i vægtkurven indikere reduceret foderoptagelse eller sygdom. Ligeledes kan en stor variation i vægten af individerne i en flok (lav ensartethed) være en indikation på sygdom eller stress/adfærdsmæssige problemer, som f.eks. et øget aggressions-niveau. Ensartetheden beregnes som den procentdel af flokken, hvis vægt ligger indenfor +/- 10% af flokkens gennemsnit. Dette tal skal helst være mindst 80%.

Figur 4 – Vægtkurve for driftsgren 472-1, 472-2 og 472-3.



Som det ses på figur 4 starter vægtkurverne for 472-1, 472-2 og 472-3 med at stige jævnt. I driftsgren 472-1 og 472-2 stagnerer kurven omkring leveuge 52/60, og vægten ender med at falde i leveuge 68, mest udtalt i 472-2. I driftsgren 472-3 er der et knæk på kurven leveuge 28, 44 og 60.

Tabel 4 – Ensartethed, i %. Gennemsnittet er beregnet på 50 høner/flok. Farverne i tabellen angiver, om ensartetheden ligger over eller under 80%.

Leveuge	182-1	462-1	462-2	472-1	472-2	472-3	502-1	502-2	872-1	872-2
20	88	88	74	**92**	**86**	**86**	80	76	86	86
24	78	78	76	**76**	**88**	**82**	88	90	90	
28	76	88	80	**78**	**76**	**72**	64	80	78	90
36	74	64	68	**70**	**82**	**80**	72	86	90	82
44	82	84	78	**86**	**84**	**76**	80	84	76	76
52	82	76	58	**80**	**78**	**88**	74	78	68	76
60	82	76	84	**78**	**78**	**88**	76	72	76	
68	80			**78**	**58**	**82**	68	72		

Som ses i tabel 4 starter alle tre driftsgrene produktionsperioden med en meget høj ensartethed, hvorefter der i leveuge 24/28 sker et fald. I driftsgren 4721-1 og 472-2 holder ensartetheden sig under 80% i sidste del af produktionsperioden, svarende til stagneringen og faldet på vægtkurven. I driftsgren 472-3 ligger ensartetheden oftest over 80%, dog med fald i uge 28 og 44.

3.5 Fødder

Der kan opstå problemer med fodhelsen i form af fodbylder hos fjerkræ. Bylderne dannes ved infektion i sår og rifter på fødderne, og er smertefulde for hønsene. Risikoen forøges, hvis underlaget består af materiale med skarpe kanter, hvis strøelsen er våd og med højt ammoniakindhold, ved inaktivitet eller et forkert design af siddepindene.

Fodhelsen er undersøgt på 50 høner/flok ved alle teknikerbesøg. Fødderne undersøges for fodbylder og bedømmes på en skala fra 1-4, med 4 som den bedste karakter (jf. afsnit 6.1).

Der er ikke set fodbylder hos alle driftsgrene. I de driftsgrene, hvor der udvikles fodbylder, er de typisk registreret i den sidste del af produktionsperioden, hvilket for alle holdene omfatter vinterhalvåret. Det er i vinterperioden, at strøelsen er sværest at holde løs og tør, og hvor hønerne må forventes at opholde sig mere inde i stalden pga. vejrforholdene.

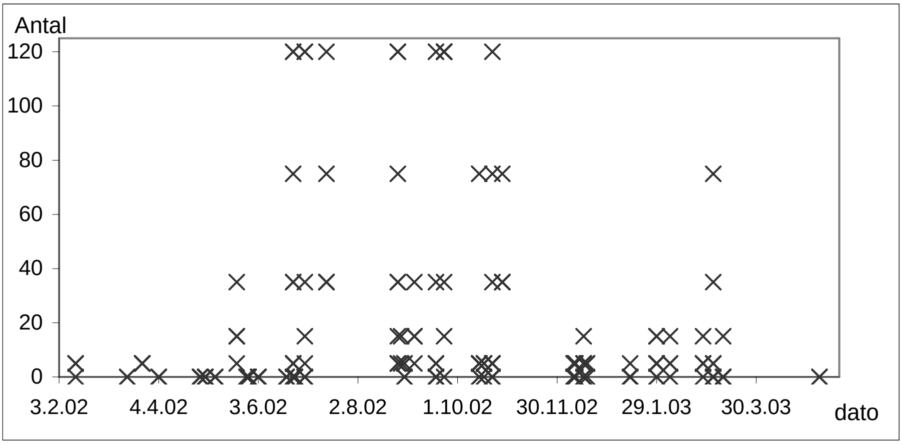
Der er ingen registreringer af fodbylder hos driftsgren 472, derfor behandles dette ikke yderligere.

3.6 Blodmider

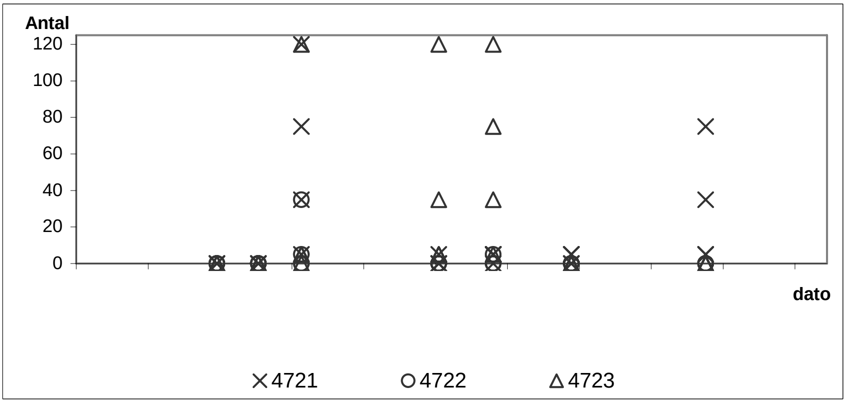
Blodmider (*Dermanyssus gallinae*) er små parasitter (-1 mm), der lever af at suge blod fra hønerne. De er primært aktive om natten, og gemmer sig i revner i inventaret om dagen. Høns med blodmider vil have kløe og være urolige, og større infektioner kan resultere i nedsat ægproduktion og blodmangel.

Tilstedeværelsen af blodmider er forsøgt estimeret ved hvert teknikerbesøg, ved opsættelse af nogle gemmer på slats eller siddepinde, hvor hønerne opholder sig om natten. Gemmerne bestod i plastikrør, hvori producenterne lagde papir ugen inden teknikerbesøget. Papiret kunne derefter let fjernes og antallet af blodmider i røret estimeres. Metoden er ikke endnu efterprøvet, og kan derfor i teorien ikke benyttes til at vurdere mængden af blodmider – kun om de er der eller ej. På figur 6 ses dog en tydelig tendens til, at mængden af registrerede blodmider stiger i sommerperioden, hvor populationen også forventes at være størst, så tilsyneladende kan registreringen give et estimat af antallet af blodmider. Det skal alligevel bemærkes, at metoden er behæftet med nogen usikkerhed, hvilket fremgår af en melding fra en af producenterne, hvis høner ikke ville sidde på slatsene grundet gener fra blodmider. I denne periode er der kun registreret blodmider fra en parallel driftsgren. Dog blev der registreret >100 blodmider i et rør hos den aktuelle driftsgren i besøget, der ligger umiddelbart forinden. Der er tillige stor forskel på antallet af registreringer mellem driftsgrenene, dels kan det være et problem at huske at ilægge papiret, og dels har hønerne i nogle tilfælde kunne tage papiret ud af røret. Alle driftsgrene har dog registreringer fordelt jævnt ud over produktionsperioden.

Figur 6 – Blodmider. Antal blodmider/rør registreret hos alle driftsgrenene. Blodmiderne er optalt i følgende kategorier: 0, 1-10, 11-20, 21-50, 50-100, >100, i skemaet angivet som hhv. 0, 5, 15, 35, 75 og 120.



Figur 7 – Registrerede blodmider i driftsgren 472-1, 472-2 og 472-3. Hver kryds svarer til optælling af et rør.



Antallet af registrerede blodmider varierer meget. I tre af driftsgrenene er der registreret meget få blodmider i samtlige optællinger. Alle andre har mellem 1 og 3 optællinger med mere end 100 blodmider i ét rør. Der er ligeledes meget stor variation mellem driftsgren 472-1, 472-2 og 472-3, hvor især driftsgren 472-2 skiller sig ud ved, at der er registreret meget få blodmider. Der er dog også stor forskel på 472-1 og 472-3, idet der i driftsgren 472-3 er registreret et større antal blodmider under besøgene i sommerperioden, mens der tilsyneladende er to separate perioder med opformering af blodmider hos driftsgren 472-1 i hhv. juni 2002 og marts 2003.

4 System og management

4.1 Belægningsgrad og indretning af huset

Tilgængeligheden af ressourcer i huset er væsentlig for hønernes velfærd. Er der knaphed på f.eks. drikkenipler, redekasser og siddepinde, vil der kunne opstå konkurrence om adgangen. Dette kan medføre øget aggression i flokken og måske resultere i, at nogle af individerne ikke kan få opfyldt deres adfærdsmæssige behov. Konkurrence om ressourcerne kan have en effekt på såvel højt som lavt rangerende høner. De højt rangerende høner vil oftere føle deres position truet, og vil reagere herpå ved at være 'kampberedte'. Dette kan på kort sigt betyde, at de ikke får ro til f.eks. at spise, og på længere sigt kan det være stressende. Modsat vil de lavest rangerende individer ikke kunne klare sig i konkurrencen om ressourcer, og derfor have problemer med at skaffe sig adgang hertil. Uhensigtsmæssig placering af f.eks. vand, foder og sandbad vil have samme effekt.

Tabel 5 – Stalddata, alle driftsgrene. Norm er det lovmæssige krav til nyopførte huse. Krav iht. overgangsordninger er ikke anført, f.eks. må stalde godkendt til 4500 høner inden 24. august 2000 fortsætte med denne flokstørrelse indtil år 2011. Tilsvarende blev arealet under siddepindene tidligere medregnet som strøelsesareal, men i stalde taget i brug efter 2002 er dette ikke tilladt længere.

	Norm	**182-1**	**462-1**	**462-2**	**472-1**	**472-2**	**472-3**	**502-1**	**502-2**	**872-1**	**872-2**
antal indsat (stk)	3000 stk	3112	4500	4500	**3500**	**3100**	**1400**	4500	3000	3000	3000
areal ude (m^2/høne)	min. 4 m^2/høne	11,3	4,2	4,1	**2,6**	**3,3**	**4,3**	3,6	5,3	1,8	1,4
areal inde, inkl. veranda (høner/m^2)	max. 6 høner/m^2	4,7	6,6	7,2	**9,4**	**8,8**	**9,7**	6,3	6,1	5,6	5,6
antal drikkenipler (stk/høne) (a)	min. 0,1 stk/høne	0,10	0,05	0,07	**0,07**	**0,02**	**0,08**	0,04	0,04	0,05	
længde foderstreng (cm/høne) (b)	min. 5 cm/høne	5,4	2,8	3,3	**3,1**	**3,9**	**3,2**	3,3	2,0	3,6	3,7
areal reder (høner/m^2 redebund)	min. 83 høner/m^2	55	120	106	**145**	**117**	**110**	64	77	56	56
længde siddepinde (cm/høne) ©	min. 18 cm/høne	10,1	17,9	16,7	**15,1**	**13,5**	**19,8**	10,3	9,3	11,0	17,6

(a) Enkelte driftsgrene har haft hængevandere. Der beregnes iflg. normen 125 hønepladsen til en hængevander, svarende til 12,5 drikkenipler.

(b) Normen er 10 cm foderplads/høne, men da foderstrengen typisk er tilgængelig fra begge sider er der kun behov for 5 cm foderstreng.

(c) Hos nogle driftsgrene er der siddepinde i slatsområdet. Her er arealet med slats omregnet til meter siddepind udfra den antagelse, at der kan være 3 m siddepind på 1m^2 slats.

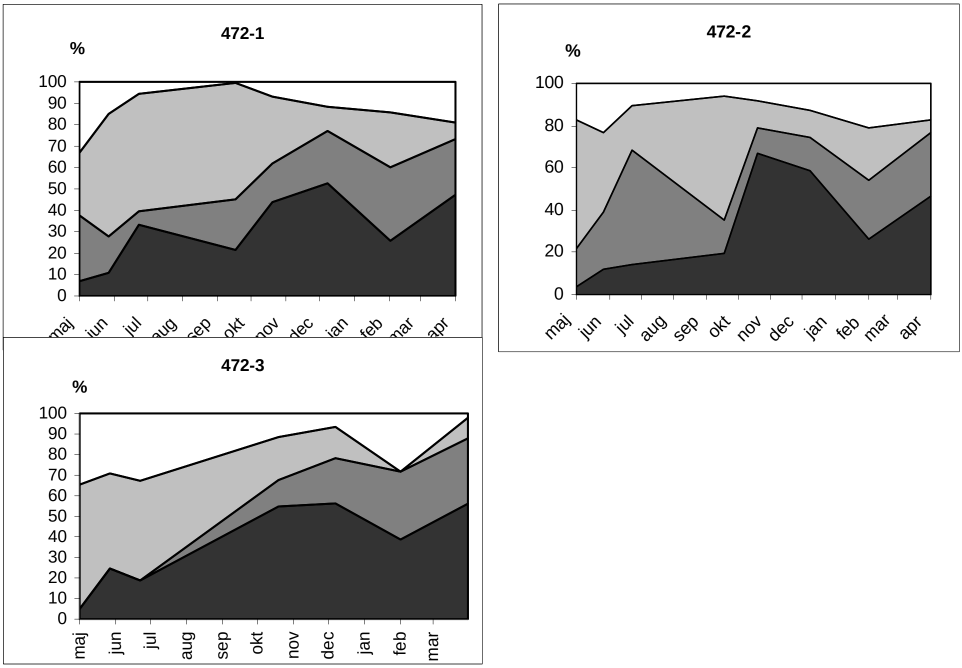
Beregnes stalddata udfra de nyeste regler er dimensioneringen af stald og inventar generelt i underkanten. Kun driftsgren 472-3 opfylder krav til udeareal, drikkenipler og siddepinde.
Redigering: hængevandere er ikke blevet medregnet i 742-2, den faktiske kapaciteten er derfor større.

4.2 Gulvareal

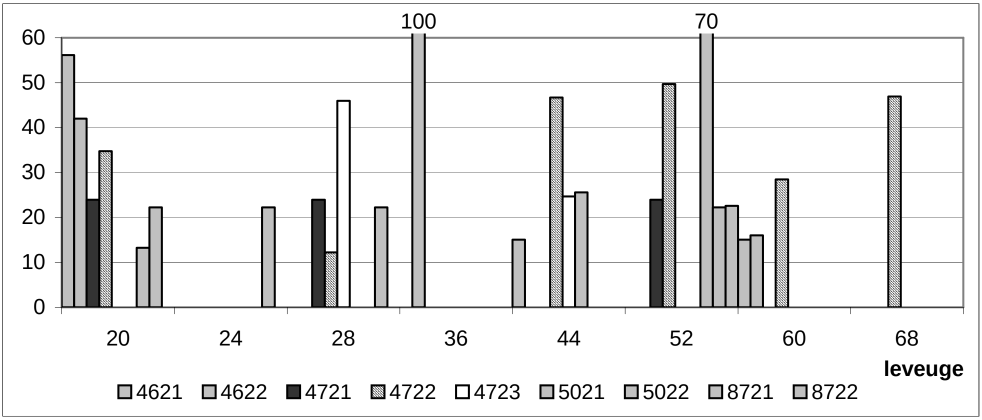
Gulvarealet i huset er vigtig for hønernes velfærd. Strøelsen skal fungere som skrabemateriale for hønsene, og således være medvirkende til at aktivere dem, men derudover bliver materialet også brugt til fjerplejen via støvbadning. Det er derfor vigtigt, at strøelsen er løs og tør, samt at der er sand tilstede til at støvbade i. Er der store mængder gødning i strøelsen, vil det kunne påvirke fodhelsen. En våd sammenklasket strøelsesmåtte vil desuden kunne fungere som et reservoir for mikroorganismer og på denne måde øge smittetrykket på flokken. Der kan typisk være nogle problemer med at holde strøelsen løs og tør i området under drikkenipler og omkring udgangshuller i perioder med vådt vejr. Ligeledes vil der være større risiko for, at strøelsen klasker sammen, hvis indeklimaet er koldt og fugtigt.

Andelen af gødning, halm og sand/jord i det øverste lag af strøelsesarealet er estimeret ved hvert teknikerbesøg. Samtidig er kvaliteten af strøelsen vurderet i form af struktur og fugtighed. Struktur vurderes efter følgende skala: helt løs, klumpet/mest halm, klumpet/mest møg, hård skorpe. Fugt vurderes efter følgende skala: tør, lidt klam, meget klam, våd.

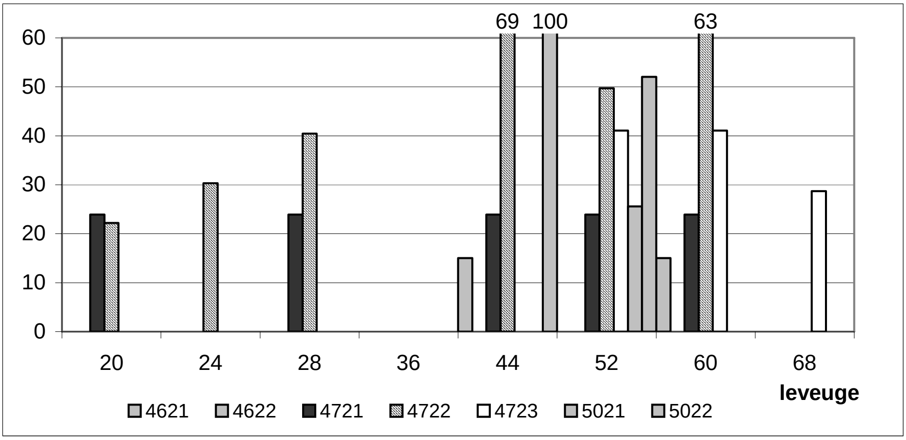
Figur 8 - Andelen af gødning (sort), halm (mørk grå), sand/jord (lys grå) og diverse (hvid) i øverste lag af strøelsesarealet hos driftsgren 472-1, 472-2 og 472-3.



Figur 9 – Struktur, alle driftsgrene. Procentdelen af strøelsesmåtten med hård skorpe.



Figur 10 – Fugtighed, alle driftsgrene. Procentdelen af strøelsesmåtten, der er meget klam eller våd.



Hos driftsgren 472-1, 472-2 og 472-3 er der rigelige mængder sand i hele produktionsperioden, og andelen af gødning på gulvarealet ligger for alle tre gennemsnitligt omkring 30%. Der er dog forskel på, hvor meget gødningsprocenten svinger mellem de enkelte målinger. I driftsgren 472-1 ligger gødningsmængden i intervallet 7-50%, men dog relativt stabilt. Der er ikke problemer med fugt i strøelsen, men pga. gødningsindholdet karakteriseres mindre end halvdelen af arealet typisk som 'helt løs'. I driftsgren 472-2 er gødningsmængden lav indtil oktober (leveuge 44), hvorefter niveauet pludseligt stiger, og følges af problemer med skorpedannelse i store dele af gulvarealet. Denne driftsgren har sammenlignet med de andre tillige en meget stor andel registreringer med meget klam eller våd strøelse. I driftsgren 472-3 stiger mængden af gødning i strøelsesmåtten jævnt hen over hele produktionsperioden. Her er dog problemer med skorpedannelse i leveuge 28 (juni) og 44 (okt.), og i sidste del af produktionsperioden kan ingen dele af gulvarealet karakteriseres som helt løst og tørt.

4.3 Grovfoder

Tildeling af grovfoder har en stor indflydelse på høners velfærd. Grovfoderet giver beskæftigelse og en øget mæthedsfornemmelse, hvilket medvirker til en roligere adfærd og mindre fjerpilning. Samtidig forbedres tarmmiljøet til fordel for hønernes sundhed.
Ved fodringen er det dog vigtigt, at grovfoderet tildeles i tilstrækkelige mængder inde i huset for således at sikre, at alle høner har adgang hertil. Ligeledes vil en stor indtagelse af grovfoder medføre en mere vandig gødning, hvilket belaster gulvarealet og kræver mere supplerende strøelse. Grovfoder bestående af stråmateriale skal være fintsnittet for at undgå forstoppelse.

Tabel 6 – Tildeling af beskæftigelsesfoder. Grovfoder samt korn/kraftfoder spredt i strøelsen betragtes som beskæftigelsesfoder.

Driftsgren	hver dag	fordelt i hus	hvad
182-1	nej	nej	ensilage i høhække mandag, onsdag, fredag - i alt 600 kg/uge
462-1/2	ja	ja	ært, lupin, byg havre hver morgen
472-1/2/3	**nej**	**nej**	**kløvergræs ensilage i udeareal 2 gange/uge - i alt 7 tons**
502-1/2	ja	nej	korn i foderrør 3/dag. Spand foder på gulv 1/uge, ensilage i hus om vinter.
872-1/2	ja	ja	75 kg ensilage/stald/dag

Der tildeles grovfoder/beskæftigelsesfoder i alle driftsgrenene, men der er nogen forskel på formålet og derved også på frekvensen og stedet. Nogle af producenterne, herunder 472, benytter tildelingen til at lokke hønsene ud af huset. Det er som udgangspunkt en god idé at lokke hønsene ud, men tildeles grovfoderet udelukkende udenfor, vil der ofte være en andel af hønsene, der ikke får suppleret deres kost med grovfoder.

4.4 Staldhygiejne

Renholdelse af stalden og inventaret er et væsentligt led i begrænsning af smittetrykket i en flok. Der bør være særlig opmærksomhed på tilsvining af drikkekar/hængevand samt redearealet. Blandt andet æggelederbetændelse kan spredes via inficerede reder.

Tabel 7 – Vandingstype og rengøring af reder.

Driftsgren	vandingstype	rengøring af reder
182-1	hængevandere	hver anden mdr.
462-1/2	nipler	1/mdr
472-1/2/3	**nipler**	**2/produktion**
502-1/2	nipler	hver anden mdr.
872-1/2	nipler	nej

Der er meget stor forskel på, hvor ofte rederne rengøres. I driftsgren 472-1, 472-2 og 472-3 rengøres måtterne i rederne 2 gange i løbet af produktionsperioden, hvilket er forholdsvist lidt sammenlignet med flere af de andre driftsgrene. Idet vandingssystemet udgøres af drikkenipler vil der typisk hverken være store problemer med hygiejne eller vandspild.

5. Adfærd

5.1 Adfærdstests

I dette projekt er nogle standardiserede tests primært beregnet til enkeltdyrs håndtering forsøgt tilpasset flokdrift. De oprindelige tests har været brugt til at vurdere dyrenes underliggende frygtsomhed, dvs. deres tendens til at reagere med frygtsom adfærd på stimuli. En vis grad af frygtsomhed er naturlig for høner, da de er byttedyr, hvis eneste forsvar er flugt. Men stiger niveauet af frygtsomhed i en flok, kan det have konsekvenser for velfærden, idet hønerne oftere vil komme i en tilstand af frygt, og dette kan på længere sigt være stressende. Samtidig kan der være fysiske begrænsninger for at reagere med flugtadfærd i en staldbygning. Dels kan det være svært at komme væk - hvilket kan stresse - og dels kan flugtadfærden resultere i skader fra kontakt med inventaret.

Testene er baseret på en registrering af hønernes reaktionsmønster ved ukendte situationer.

Afstand: Hønernes afstand til en testperson, der går roligt gennem huset, registreres på følgende skala: 0-1 m, 1-3 m, 3-5 m, 5-10 m.

Bevægelse: Hønernes reaktion på en testperson, der går roligt gennem huset, registreres på følgende skala: kommer imod, ingen reaktion, flytter sig langsomt, flytter sig hurtigt, panik.

Lyd: Hønernes reaktion på pludselig lyd i form af to korte bank på metal registreres efter følgende skala: kommer imod, ingen reaktion, flytter sig, panik.

Reaktionstid: Reaktionstiden til hønerne pikker på et ukendt objekt (ringbind) registreres i følgende kategorier: 0-5 sek., 5-15 sek., 15-40 sek., >40 sek.

Disse tests kan muligvis give et indtryk af hønsenes frygtsomhed, men det er vigtigt at bemærke, at resultater fra testene endnu ikke er validerede. Samtidig skal det bemærkes, at mange faktorer kan have en indflydelse på resultaterne, blandt andet er det kendt, at reaktionstiderne vil ændres med alderen. Der vil ligeledes være stor forskel mellem de forskellige afstamninger, hvor de hvide afstamninger typisk reagerer kraftigere end de brune.

Tabel 8 – Frygttests. Antal tests, hvor hønernes reaktion tyder på en højere grad af frygtsomhed. I de to første kolonner angives hhv. antal registrerings-runder (alle fire tests udføres i hver registrerings-runde) og antal runder, hvor mindst én test tyder på frygtsom adfærd

	Antal runder		**Afstand**	**Bevægelse**	**Lyd**	**Reaktionstid**
	i alt	**m. frygt**	**> 3 meter**	**flytter sig hurtigt**	**flytter sig**	**15<40 sek.**
182-1	9	7		4	4	2
462-1	7	1	1	1		
462-2	7	3				3
472-1	**8**	**6**	**1**	**4**	**3**	**1**
472-2	**8**	**6**		**3**	**3**	**1**
472-3	**8**	**3**	**1**	**1**	**2**	
502-1	8	4		1		3
502-2	8	2				2
872-1	7	5		5	1	2
872-2	5	5	3	5 (inkl. 1 panik)	3	1

Driftsgren 472-1 og 472-2 reagerer med frygtsom adfærd på 6 ud af 8 runder med adfærdstests, mens driftsgren 472-3 kun reagerer frygtsomt på 3 runder.

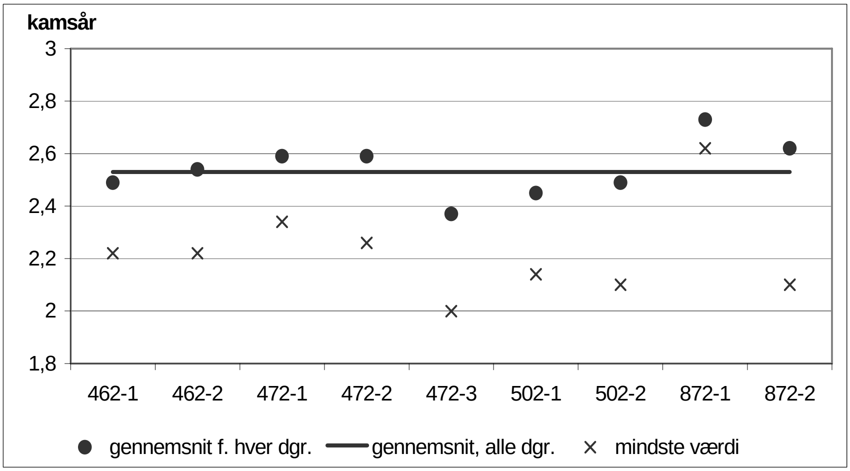
5.2 Sår

Skader/sår er smertefulde ved pådragelse og kan være adgangsvej til infektioner. Desuden kan tilstedeværelse af sår fokusere andre høners opmærksomhed, og i nogle situationer eskalere til kannibalisme. Sår opstår typisk som følge af aggression, fjerpilning, kannibalisme eller ved uheld/skader ved inventaret. Placeringen af sår afspejler til en vis grad årsagen, idet *aggression* almindeligvis er rettet mod hoved/kam, *fjerpilning* udbredes fra ryg til hale og vinger, *kannibalisme* er typisk rettet mod kloak eller sår fra fjerpilning og *skader fra inventaret* vil formentlig ses på hals, vinger, ben og bryst. Perioder med hård frost kan også give skader på især kam og fødder
Alle sår er vurderet efter følgende skala: 3: ingen skader, 2: enkelte sår (mindre end 5 hak/ar), 1: meget medtaget (mere end 5 hak/ar, blodig).

5.2.1 Sår på kam

Antallet af sår på kam er stigende med alderen hos næsten alle driftsgrene, hvilket er at forvente eftersom ar også er inkluderet i registreringen. Alle driftsgrene ligger i intervallet 2,7-3 i leveuge 20, og derefter falder de fleste til niveauet 2,2-2,5 i sidste del af produktionsperioden. Som det ses på figur 11, er det samlede gennemsnit for alle driftsgrenene i hele produktionsperioden 2,53. Driftsgren 472-1 og 472-2 ligger umiddelbart over dette niveau, mens 472-3 falder noget nedenfor. Der er overordnet set registreret meget få skader med karakteren 1, 31 tilfælde i alt, og af disse ses 21 i driftsgren 472-3.

Figur 11 – Kam-sår, samlet gennemsnit for alle driftsgrene i hele produktionsperioden, og mindste værdi samt gennemsnittet for de enkelte driftsgrene. Ved hvert teknikerbesøg er der udregnet et gennemsnit udfra bedømmelsen af 50 høner.



5.2.2 Sår på hals, vinger, ben og bryst

Der har generelt ikke været registreret mange skader på de bedømte høner, hverken hvad angår antal registreringer, hvor der er høner med sår, eller omfanget af skaderne (et gennemsnit på f.eks. 2,96 svarer til, at der er fundet to høner med karakter 2, og 48 høner med karakter 3 i en bedømmelse). Hos driftsgren 472-1 og 472-2 er der især noteret skader på rygområdet, hvilket kunne tyde på skader fra fjerpilning. Hos driftsgren 472-3 er der fundet lettere skader på halsen i 3 registreringer, og da skaderne stort set er begrænset til halsen, skyldes det formentlig slid/slag mod inventaret.

Tabel 9 – Sår på hhv. hals, bryst, ryg, vinger, hale og ben/fødder. Tallene i tabellen angiver de gennemsnits-score, der har ligget under tre.

	Hals	Bryst	Ryg	Vinge	Hale	Fod
182-1	2,98	2,98	2,96	2,98 / 2,96 / 2,92		
462-1	2,86	2,96 / 2,94 / 2,96				
462-2	2,98 / 2,94 / 2,8	2,98 / 2,98 / 2,96			2,98	2,98
472-1	**2,98**	**2,96**	**2,9 / 2,92 / 2,9 / 2,88**			
472-2		**2,98 / 2,82**	**2,94 / 2,94 / 2,96 / 2,88**		**2,96**	
472-3	**2,96 / 2,98 / 2,98**	**2,96**				
502-1	2,86 / 2,58 / 2,9	2,94 / 2,78 / 2,68 / 2,76	2,84 / 2,54 / 2,48	2,94	2,98 / 2,88 / 2,4 / 2,52	2,98
502-2	2,88 / 2,76 / 2,96	2,96 / 2,6 / 2,76	2,94 / 2,46 / 2,58		2,98 / 2,94 / 2,1 / 2,76	
872-1	2,92 / 2,94 / 2,96	2,98	2,98 / 2,98			2,98
872-2	2,34 / 2,78	2,98 / 2,76 / 2,96	2,86 / 2,9 / 2 / 2,44		2,8 / 2,9	

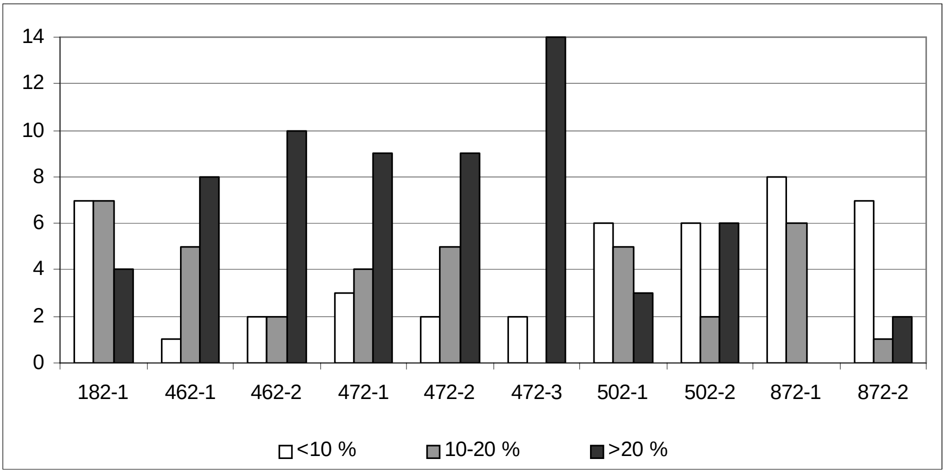
5.3 Andel høner i udeareal

Et varieret udeareal kan aktivere og stimulere hønerne, og samtidig vil brugen medføre, at flokken spredes mere, dvs. de enkelte høner får mere rum til pladskrævende aktiviteter, og huset/strøelsen belastes mindre.
Antallet af høner, der benytter hønsegården, kan variere meget mellem to registreringer, fordi det bl.a. afhænger af vejrforhold, tidspunkt på dagen og alder/erfaring. Der vil også forventes en stor forskel mellem flokkene, dels fordi vejrforholdene på registreringstidspunkterne varierer mellem flokkene, men der er også andre faktorer, der spiller ind, som bl.a. hvor attraktiv hønsegården er for hønerne, race/afstamning, indsættelsestidspunktet samt niveauet af frygt og stress i flokken.
I udearealet vil hønerne typisk fordele sig således, at langt de fleste forbliver i umiddelbar nærhed af huset, og tætheden vil falde, jo længere man kommer fra huset. En attraktiv hønsegård kan medvirke til at sprede hønerne mere og dermed mindske forureningen og smitterisikoen omkring huset, samt aktivere hønerne i udearealet.

Tabel 10 – Gennemsnitligt antal høner i udeareal, angivet i procent af total. Standard afvigelsen (std. afv.) angiver grad af variation i optællingerne.

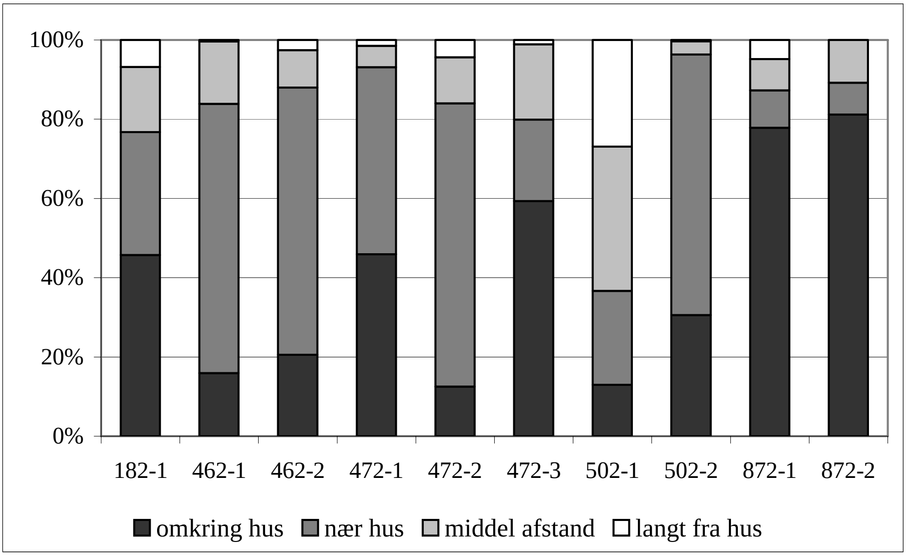
	182-1	462-1	462-2	472-1	472-2	472-3	502-1	502-2	872-1	872-2
Gnsn. % høner ude	12,1	20,3	32,1	21,2	22,4	37,9	12,9	19,1	9,9	7,3
Std. afv.	7,1	8,9	19,0	12,7	12,0	20,6	11,1	15,2	5,7	7,7
Antal registreringer	18	14	14	16	16	16	14	14	14	10

Figur 12 – Antal ude. Antal registreringer med hhv. <10%, 10-20% og >20% høner i udearealet.



I alle driftsgrenene er der gennemsnitligt observeret mere end 20% af flokken i udearealet (jf. tabel 8), og især 472-3 skiller sig ud med 14 ud af 16 af registreringer i kategorien '>20%' (jf. figur 12). Der skal dog tages højde for at registreringerne er foretaget under forskellige vejrforhold (jf. appendiks 6.5). Fordelingen i udearealet er som forventet skæv, med det største antal høns i umiddelbar nærhed af huset (jf. figur 13). Her ser det dog ud til, at mange høns trækkes lidt væk fra udgangsområdet i driftsgren 472-2, og at fordelingen i arealet er relativt jævn i driftsgren 472-3, når først hønerne er kommet lidt væk fra huset.

Figur 13 – Den procentvise fordeling af høner i hønsegården. Tallene er udregnet udfra det samlede antal høner observeret i udearealet under hele produktionsperioden. Bemærk dog, at afstanden til de forskellige zoner (omkring, nær, middel, langt) varierer mellem driftsgrenene (jf. appendiks 6.6).



Appendix 3

The suggested control points, critical limits, monitoring frequencies and corrective actions in the generic HACCP-like system are given in Table 2. If experts suggested different critical limits or monitoring frequencies for the same control point, all are mentioned, separated by a "/". The control points relation to hazards and their associated risk factors can be determined using the H*RF-code. The H*RF-code refers to the combination of a hazards and a risk factors given in Table 1.

Table 1 The H*RF codes referring to a combination between a Hazard and a Risk Factor

H*RF	Hazard	Risk Factor
A1	Blackhead	Poor pasture management
A2		Poor clean out between flocks
B1	Bone fractures	Poor/rough handling during catching
B2		Rough handling during production period
B3		Bad /broken equipment and equipment with sharp edges
B4		Poor diet
C1	Cannibalism	Low stimulation (poor quality litter, no roughage, no grains in litter, no access to outdoor area)
C2		Poor management of pullets in rearing
C3		Poor diet
C4		No action at first signs of cannibalism
C5		Occurrence of wounds
C6		Feather pecking
C7		No elevated perches / lack of adequate perch use
C8		Physiological stress at onset of lay
D1	Crop impaction	Feed deficiency, which make hens eat everything
E1	Hunger	malfunctioning feeder system
E2		electricity failure
E3		Pathology (e.g. crop distension)
E4		Illness/injury preventing movement or preventing eating
F1	Pasteurellosis	No disease identification when mortality rises (=> no vaccination of the next flock)
F2		No vaccination of 'high risk' flocks
F3		Poor clean out between flocks
G1	Piling	Nervousness / fearful hens
G2		Not enough habituation to environmental stressors during rearing
G3		High stocking density
H1	Predators	Poor fencing
H2		Insufficient closing of pop holes at night
H3		Security of house/holes in the house
I1	Red mites	High temperatures
I2		Poor hygiene during the production period
I3		Underestimation of consequences if number of mites rises
I4		Delayed treatment if number of mites rises
I5		Poor house and furniture design providing hiding places for mites
I6		Insufficient cleaning and disinfection between flocks
J1	Thirst	Thermal stress (high temperature)
J2		Malfunctioning water system (pipes, drinkers)
J3		Insufficient supply
J4		Animals too small to reach drinkers
J5		Illness/injury preventing movement or preventing drinking
J6		Not enough drinkers
J7		Poor accessibility of water

Table 2 Control points, critical limits, monitoring frequencies and corrective actions.

H* RF	Control Point	Frequency	Critical limit (specification of cp)	Corrective action
C1,G1	access to straw bales	daily	no access for all birds no straw bales indoor and outdoor	distribute straw bales in house and outside
C1, C6	grains in litter	daily/every second day	less than x g/ hen not spread equally around the house	spread grains
C5, E3, E4, J5, J1,E1	bird appearance (crop distensions, illthrift, injuries, heat stress)	(1-3) 1/2/5 times per day (4) hot summer days	(1) signs of crop distension (2) inactive birds, birds with ruffled feathers, swellings around head (3) hens with wounds, limping or otherwise injured hens (4) panting, wings slightly lifted, low activity level	(1) cull birds, outdoor: cut grass to max 5 cm length, give only fine cut hay as roughage (2) check mortality figures. Send 10 dead hens for post mortem examination. Contact advisory service. Add plenty, fresh litter, ensure good indoor climate (not too hot), plenty of roughage, no stress. If pasteurella is detected, then apply for permission to vaccinate next flock. (3) isolate/cull hens. If outbreak of cannibalism: darken house, activate hens (4) lower temperature with ventilator/pop holes/windows
I3, C1, C4, C6, C5, G3	bird behaviour (distribution of birds, aggressors, level of activity, nervousness)	(1) weekly (2-4) 1/2/5 times per day	(1) unequal distribution (2) aggressive peckers (3) inactivity (4) nervousness	(1) locate cause, and compensate if possible. Attract birds to other areas using grains, roughage, hay (2) remove aggressors (3) activate hens with roughage, grains, fresh litter and/or straw bales create attractive outdoor area (trees, bushes, straw bales, piles of branches etc.), sand bath. Increase observation
J6, J3, J7, J4	bird behaviour by drinkers	(1) weekly-monthly (2) daily-weekly until 6 months	(1) birds waiting, aggression around drinkers (2) birds stretching to reach water	(1) add drinkers (2) adjust drinker heights, add alternative drinking points on floor
C3, E1	bird behaviour by feeding line	daily	frustration, aggression by feeding line	Check if feeding line is functioning. Locate error and repair. Give feed manual if feed failure is not corrected within 2 hours Check if hens refuse to eat new food (bad taste or structure), offer alternative food. Contact manufacturer. If feeding line is functioning and food is eatable: add additional feeding line and feeding times. If problem persists provide straw/roughage for activity purposes/distraction
G1	bird behaviour in response to keeper	daily	fearful reaction to keeper (moving fast away, panic)	more inspections feed manually (e.g. grains) review attitude/behaviour towards hens
C7	bird behaviour on perches	weekly in period of 1 month after starting flock, then monthly (morning or evening)	aggression	install more perches install perches at different heights lower perches
B3	bird movement (to perches, to nests, in/out of house)	daily-monthly, when flighty	problems with access/movement	repair, add latters

C1, C4, C6, C5	bird soundings	1/2/5 times per day whenever in house or egg packing room	cannibalism (wounds): sounds of distress, increased sound level cannibalism (understimulation): increased sound level cannibalism (feather pecking): feather pecking "cries"	activate hens with roughage, grains, fresh litter and/or straw bales create attractive outdoor area (trees, bushes, straw bales, piles of branches etc.), sand bath increase observation
C8	bird weight (50 hens)	weekly	less than average weight according to breed standards no weight increase.	more energy in feed delay onset of lay by keeping light stimuli low (8-9 hours)
C6	feather test	weekly	response of hens on a downy feather falling from 1 meters height	increase observation activate hens check quality of feed improve indoor conditions
C6	feathers on the floor	daily	no feathers on the floor	increase observation activate hens check quality of feed improve indoor conditions
C4	first sign of feather pecking	1/2/5 times per day	beginning feather pecking (lower back) no feathers on the floor loud sounds ("feather epcking cries")	improve activation (grains in litter, fresh litter, roughage, stimulate use of outdoor area) secure indoor climate (dry friable litter, no ammonia, temperature within recommended range) secure special needs (housing density, perches, nests, feed line, water nipples, litter area, sand bath) check quality of feed
C4	first wounds	1/2/5 times per day	first wound around tale base injured birds	remove injured birds if outbreaks of cannibalism: dim light, red light activate hens improve indoor conditions (litter, ammonia, space) increase observation check quality of feed
C7	hens on floor at night	daily in period after starting new flock, then monthly	hens on floor at night	install more perches install perches at different heights lower perches provide more activity during daytime (carrots, hay)
I4, I5	check for mites: nests, poorly exposed areas, raised floors/perches	weekly	presence of mites	scatter silicat powder spray oil scatter stone dust scatter hydrated lime control mites with cardboard traps (100-200x140x3 mm), remove and burn every second day
I4, I5	check for mites: traps	weekly	increase in number of mites in trap	check equipment for possible hiding places: repair, clean scatter silicat powder spray oil on colonies scatter stone dust scatter hydrated lime trap mites with cardboard traps (100-200x140x3 mm) hung under perches, remove and burn every second day
C4	check house for presence of dead hens (litter, nests)	1/2/5 times per day	dead hens	remove immediately

F1	mortality	daily	if mortality > 1,2% per month (not caused by piling) or mortality >=1% per week or mortality >0.5% per day	send 10 dead hens for post mortem examination If pasteurella is detected, then (1) add plenty, fresh litter, ensure good indoor climate (not too hot), plenty of roughage, no stress. (2) contact advisory service (3) Apply for permission to vaccinate next flock.
E3	post mortem examination of dead birds	when dead birds	crop impaction	cut grass to max 5 cm, check feed composition,
C8	egg production (start)	daily	(1) start of egg production more than 1-2 weeks before recommended age	(1) more energy in feed. Delay onset of lay by keeping light stimuli low (8-9 hours)
C3, D1, E1	egg production, (low level, sudden drop)	daily	5% below target (standards for age, breed + historical data for site) Sudden drop	Check feed consumption: if low: check good feed availability: add feeding line, feeding times, repair system failures. Check if hens refuse to eat new food (bad taste or structure): provide new food, contact manufacturer Check for signs of diseases (mortality, illthrift, droppings): contact advisory service If cause is unidentified: take feed samples and analyse for nutrient content.
C3, B4	egg shell quality	when packing eggs	soft, thin or porous shelled eggs (after starting the laying period)	give extra vitamins and minerals check food consumption and food plan: is consumption and composition according to standards check for signs of disease (illthrift, droppings and mortality figures): contact advisory service
C3	egg weight	daily	lower than standards given by breeding company	check food composition (too little protein)
D1	access to grit	daily	no access for all birds	provide grit in house, at several points in house
C1, C6, G1	access to roughage	daily/every second day	no access for all birds	distribute roughage in house and outdoor distribute enough roughage for all birds
B4	access to shells	daily	no access for all birds shells	provide shells in house, at several points in house
C3, C6, C8, D1, B4	feed plan (with standards for different age/weight groups and adjustments for start of egg production)	when ordering new commercial feed/when composition own feed	feed plan not according to recommended standards feed plan not adjusted for differences in weight and start of egg production	adjust feed programme to fit with hen weight correct feed according to plan
C1	feed structure	when purchasing feed	not mash diet	change to mash diet
C3, D1, E1	food consumption	daily-weekly	5% below target (standards for age, breed + historical data for site)	check for malfunction, repair check if feed line runs empty within 5 minutes, or no feed reaches the far end: add feeding times check if hens have restricted access: add feeding line check for illthrift, contact advisory service check for unwillingness to eat (distaste, wrong structure): contact manufacturer and supply other feed stuff If problem unidentified: sample feed and analyse for nutrient content.

				Correct deficiencies. too high consumption can indicate wrong food composition (too little energy in food)
D1	food in feeding line	morning and 2 hours before last feeding	if empty after 5 minutes	add feeding times
B4, C3, C6	nutrition analysis of raw material (for production of own food)	when getting new raw material	deviations from feed recommendation	correct feed according to plan
D1	length of hay used for roughage	when preparing/buying roughage	not fine cut (x cm)	fine cut the hay
B4, C3, C6, D1	quality control of feed at manufacturer	when changing manufacturer	quality control securing correct composition of food and no distaste	change supplier, take food samples for later analysis
J2, J3, J6	water consumption	daily	above expected below expected	check for system failure and/or leakings repair check temperature, increase ventilation add drinkers check for illthrift/mortality, contact advisory service
G3	density at housing	when ordering pullets at the rearer	more than 4/5/6 hens/m2	order fewer chickens
G1	knowledge of breed temperament/behaviour	before ordering	use breed appropriate for caretakers temperament avoid breeds with high tendency to fearfulness	order appropriate breed
G3	group size	when ordering pullets at the rearer	more than 3000 hens per flock	order fewer chickens
I6	log for level of infestation in previous flocks: mites	after cleaning	levels of mites high enough to initiate treatment 1/2/3 times during the production period	heat treat building and equipment (55 degrees in 48 hours)
F2	log for level of infestation in previous flocks: pasteurellosis	1 month before starting new flock	lab results showing pasteurellosis in samples	apply for permission and order vaccination, ensure that flock is vaccinated at arrival
I2	cleanness of equipment (drinkers, feeding line, nests, perches)	daily / twice per week	clumps of manure on equipment	clean equipment
A2, I6, F3	cleaning material/disinfectants	when cleaning between flocks	not use of cleaning material and disinfectants allowed for organic production	change products
A2, I6, J3, F3	effectiveness of cleaning procedure (house, nests, feeding system, water system, perches)	when cleaning between flocks	dirt in/on: house, nests, perches, feeding line, water system (incl. deposits in pipes) after cleaning	improve cleaning, flush water system and decalcify
C1, C6, I2	litter quality	daily	less than 90% dry and friable (can easily be turned with foot) top layer predominately litter material not manure	fork the litter, top-up with fresh material spread grains in litter adjust ventilation
A2, F3	cleaning procedure outside	when cleaning between flocks	top 10 cm soil in area closest (5-10-20 meters) to house removed spread hydrated lime in area fill the area with 5-10 cm sand and top with mussle shells	remove soil use hydrate lime
C1	sufficient area for sand bath	before starting flock	minimum x m2 per hen	increase area with sand

C1, C8, I2	sand bath quality	daily/twice per week	less than 90% dry and friable (can easily be turned with foot) top layer predominately sand not manure/straw	fork the sand bath, top-up with fresh material adjust ventilation
I6, F3	time laps between cleaning and new flock	after cleaning between flocks	minimum 2 weeks empty house after cleaning	delay installing new flock
F3, I6	use of hydrauted lime	after cleaning	not spread in entire house	spread lime in all house
A2, I6, F3	water temperature when cleaning	when cleaning between flocks	water temperature minimum X degrees	
I1, J1	thermometer	daily/weekly when alarm sounds	(1) <0 °C (2) <5°C (good plumage)/<13°C (bad plumage) (3) >25 °C (4) >30°C (winter)/ 35°C (summer)	(1) secure water from frost (2) increase temperature in house (ventilation, pop holes, isolation) (3) check for mites, treat against mites (4) lower temperature (ventilator, windows, pop holes)
A1	management of permanent pastures	in summertime	pasture not chain harrowed according to plan	chain harrow
A1	drainage of outdoor area	daily	pools of water on ground	fill pools, improve drainage
A1	number of birds in the range area	every two weeks/every month	(2) less than x% of flock in outdoor area and more than x% within 20 meters from the house on a fine (no rain/no wind) summer day	improve outdoor area (vegetation, cover)
D1	old grass in pasture	weekly	more than x %	cut old grass
A1, C1, C6	outdoor area, quality	weekly/every two weeks/monthly	no cover within 20-100 metres from house (trees, bushes, vegetation etc)	ad cover, straw bales, pile of branches, sew fields with e.g. maize, plant trees, bushes in permanent pastures
A1	pasture rotation according to plan	every 1½/six month/between flocks	pasture not rotated according to plan	change pasture
C2, C8, G2	check rearers reputation among other producers	before ordering pullets	unsatisfactory rearing conditions unsatisfactory pullets delivered to other producers	find another rearer
C8	housing condition in transition from rearer to producer	before starting new flock	(1) max 1 hour increase in light from rearer to production, if placed in summer: 12 hours daylight, starting as 18 weeks (2) ensure same type of drinkers as rearer (3) ensure the same feeding composition/type/procedures as rearer (4) not all birds finds water, food and perches when starting	(1) adjust light programme (2) install same type of drinkers as rearer (3) use the same feeding composition/type/procedures as rearer (4) move hens to perches/slats at night
C2	information from rearer	at delivery	no information on weight development/deviation (6 weeks, 10 weeks, at delivery), vaccinations, behavioural problems, daily mortality, disease history, indoor climate	ask for information change rearer

C2, C6, C7, G2	specify rearing conditions in contract with rearer	when ordering	ensure: (1) daily access to daylight from day old (2) access to perches at heights fitting birds from day old (3) straw in all parts of house fresh, dry and loose straw from 1/3 days of age (4) access to range from 3/12 weeks (5) daily access to roughage from day 1/7 roughage enough for whole flock (6) minimum 2/5 daily inspections (7) hens are perching (training) (8) light program (9) vaccinations	add to contract
C2	visit rearer (play a radio, check if contract is fulfilled, inspect birds)	once (8-10 weeks of age)	rearing conditions not corresponding to contract signs of nervousness signs of aggression, feather pecking	claim to have contract terms fulfilled claim more activation, more inspections
C2	weigh (spread) of pullets	when starting the new flock	weight spread of 50/100 hens < 80 (less than 80% of the hens has a weight within the frames 'average +/- 10%') average weight according to breed standards	increased attention on behavioural problems, weight development, feed plan, light plan, period until peak of lay
G3	barriers in house separating flock into smaller groups	before starting new flock	not enough barriers to separate flock into groups of 100-500 birds	add barriers
H2	check pop holes (open/closed)	every evening	open pop holes	close/repair
H1	condition of fence	daily-weekly	holes in fence access under fence high grass by fence no electricity	repair holes stop access under fence cut grass find error - repair
D1, G3, J7	distribution of equipment (drinkers, feed line, nests, perches, sand bath)	when installing equipment	not equal distribution of equipment max X meters from anywhere in the house to the nearest drinker max X meters from anywhere in the house to the nearest feed line	ensure equal distribution of equipment, add equipment if necessary
C6	distribution of pop holes	before new flock is started	equally distributed throughout house xx metres exit per 100 hens	add pop holes
J4	drinker height	daily - weekly until 6 months	drinker height not appropriate for birds / not at level with birds back	adjust drinker heights, add alternative drinking points on floor
J6	drinker space/hen	when starting flock	nipples: 1 drinker/ 10 hens troughs: minimum 1 cm/hen	add drinkers
E2, J3	electricity system, functioning	when alarm sounds	system failure	repair or contact electrician
E1, E2	feeding line functioning (in house)	daily/ twice per day	spilage line is not running	give feed manual if failure is not corrected within 2 hours locate error and repair, adjust, clean, call electrician

D1, E1	feeding space/hen	before starting new flock	line: 10 cm/ hen	add feeding line
C7	food and water availability on raised perches	when installing perches (before new flock is started)	no feed and water available on perches	correct
B3, C7, J5	height of perches/slats and nests	when installing equipment	(1) max. jumping height: 70 cm (2) minimum 5 cm from lower surface (3) perches at different heights	(1) add latters, lower perches/nests (2) raise perches (3) install perches at different heights
C8	housing conditions	daily	not good access to all resources litter not dry, friable indoor climate with high dust/ammonia level (is it pleasant for yourself…?)	add more perches, feed line, drinkers fork up litter and top with new material ventilate, adjust temperature
C8	light programme	before starting new flock	not according to recommended standards not adjusted for differences in weight and start of egg production	adjust light programme to fit with hen weight
D1, E1	maintenance of all parts of feeding system	every month-every sixth month	spilages, loose joints	repair, tighten joints
J2	maintenance of all parts of water system	every month	leakings, loose joints	repair, tighten joints
B3, C5	maintenance of equipment in house	daily	broken equipment or presence of pointing obstacles or obstacles with sharp edges	repair or remove
H3	maintenance of house	daily - every 6 months	holes big enough for predators	repair
J1	maintenance of ventilation system	between flocks when alarm sounds	malfunction	repair
I5	mite hiding places in equipment	when installing/purchasing new equipment /every second week	cracks and crevices that can be avoided using another design/material or filled out	use another design to avoid cracks and crevices, repair
C7, J5	perch design	when installing perches (before new flock is started)	perches must be wooden (hardwood), rounded corners, 2,5cm flat top	change perch design
C7	perch space/hen	when installing perches (before new flock is started)	less than 18 cm/hen.	add more perches
J2	water in drinkers	daily/ twice per day	no water in nipples/troughs	give water manual if failure is not corrected within 2 hours locate error and repair: adjustments, leakings, dirt
B1	careful handling in/out of transport box	when catching	not careful handling	handel according to recommendations
B1	carrying practice	when catching	hens carried in one leg more than 5 birds carried at same time	handel according to recommendations
B1	catch hens in the dark	when catching	to much light	handel according to recommendations
B1	ensure that catching team is instructed on handling practice	before catching	hens not handled according to instructions	instruct team

B2	ensure that staff is instructed on correct handling practice	before starting working with the hens	no instruction	instruct caretaker
B1	ensure that the crates have good access	when catching	bad access to crates	handel according to recommendations
G1	exposure to different situations/objects	daily during first month	hens not exposed to new situations/objects	introduce new objects/clothes/persons in house work in house (e.g. install perches)
G1	exposure to different sounds	daily during first month	hens not exposed to new sounds	play a radio, talk, work
G1	number inspections/visual contacts	1/2/5 times per day	not enough inspections/human contact	more inspections
I3, I4	staff training: getting information about red mites	when new staff	staff don't recognise red mites (colony) staff don't know usual hiding places and activity pattern staff don't know consequences of red mites	train staff
C4, C5, C6	staff training: getting to know relaxed behaviour, sound of hens	daily	les than 5 minutes daily quiet observation	take time to observe
B1	Use a well-known team of catchers	before catching	unknown team	instruct team, watch handling

SUMMARY

Animal health and welfare is an important part of organic husbandry, both in terms of the organic principles and owing to the consumer interest. But problems in the organic egg production resulting in high mortality and feather pecking, have led to the need for management tools in order to secure animal health and welfare.

The aim of the project is to develop management tools for the organic egg production, aimed to secure animal health and welfare in the flocks.

In the first part of the project a welfare assessment system for organic egg production was developed and tested on 10 flocks during one production period. In the second part of the project a generic HACCP system was developed, using an expert panel analysis. The two management tools have very different approaches to improving animal health and welfare, and subsequently different methods, cost and advantages. This makes them relevant for different purposes and by different producers and interested parties.

PLANT SCIENCE

HORTICULTURE

ANIMAL SCIENCE

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