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The LayWel project: welfare implications of changes in production systems for laying hens

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The conditions under which laying hens are kept remain a major animal welfare concern. It is one of the most intensive forms of animal production and the number of animals involved is very high. Widespread public debate has stimulated the call for more animal friendly, alternative systems to barren conventional cages.
Directive 1999/74/EC has encouraged technical changes in current systems. Not only have traditional cages been modified (so-called 'enriched cages'), but also new alternative systems (e.g. aviaries) have been developed. There is an ongoing need to evaluate the actual welfare status of hens in these novel systems including those on commercial farms.
The LayWel project, was funded via the European Commission's Sixth Framework Programme and national funding from several EU countries. Its general objective was to produce an evaluation of the welfare of laying hens in various systems, with special focus on enriched cages, and to disseminate the information in all member states of the EU and associated countries. The project took into account pathological, zootechnical, physiological and ethological aspects.

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A major achievement of the LayWel project was the compilation of a database collecting data from different housing systems and thus enabling data comparison. The project partners recommend that support is given to maintaining the database in the future so that data can be more reliably modelled.
As the type of data collected did not often allow a formal statistical analysis the evaluation of welfare was a presentation of risk factors and advantages and disadvantages of various housing systems. Conclusions are that, with the exception of conventional cages, all systems have the potential to provide satisfactory welfare for laying hens. However this potential is not always realised in practice. Among the numerous explanations are management, climate, design, different responses by different genotypes and interacting effects.
A second major achievement of the project was the development of feather scoring and integument (skin, head and feet) scoring systems together with comprehensive sets of photographs.
It is recommended that the integument scoring systems are widely adopted and used in on-going research. Farms should also routinely and frequently carry out integument scoring to assist in the detection of damaging pecking, which is currently a widespread welfare problem.
Within LayWel an on-farm auditing procedure was developed in the form of a manual for self-assessment. The manual first explains what is meant by welfare and outlines the relevance of welfare assessment. It also summarises risks to welfare in the main categories of housing system. The second part contains recording forms, with guidance for assessing hen welfare. These enable regular checks of a range of indicators of laying hen welfare to be carried out systematically. The indicators were chosen to be relevant to hen welfare as well as feasible and reliable to apply in practice.
A series of conclusions and recommendations were made on various aspects of housing systems, behaviour, health and mortality and other matters in relation to bird welfare. Full details of these and all other aspects of the LayWel project can be found on www.LayWel.eu. The information is also available on CDROM of which copies are freely available on request.

Keywords: laying hen; behaviour, welfare; housing system; health; mortality; physiology; productivity; integument scoring

Introduction

The conditions under which laying hens are kept remain a major animal welfare concern. It is one of the most intensive forms of animal production and the number of animals involved is very high. The total egg laying flock in Europe comprises approximately 250 million birds. The birds are reared either in cages or on the floor until their transfer to laying houses just before lay (15-18 weeks). Although a growing proportion is then kept in alternative systems, the predominating system for the production of eggs in the EU is still the conventional battery cage. The degree of confinement in battery cages and their barren, invariant nature have elicited significant public concern over the past 30 years. Indeed, housing hens in such battery cages has been associated with increased fear, stereotyped behaviour and bone weakness and with reduced behavioural repertoire (Mills and Wood-Gush, 1985; Knowles and Broom, 1990; Appleby and Hughes, 1991; Jones, 1996).

Widespread public debate has stimulated the call for more animal friendly, alternative systems. In the EU, Council Directive 88/166/EEC (EC, 1988) specified minimum space allowances as well as other aspects of housing laying hens, but this provided only minor improvements as birds were for instance still prevented from performing several of their basic behaviours. In 1996 the Scientific Veterinary Committee (an advisory body to the European Commission) published a report on the welfare of Laying hens (ECScVC, 1996), which formed the basis for further debate on the housing of laying hens. In 1999 Directive 1999/74/EC setting-down minimum standards for the protection of laying hens was put into force (further on referred to as "EU-Directive"). This Directive restricts the housing of laying hens in the EU to three different categories of farming systems: unenriched cages, alternative systems and enriched cages. The term "unenriched cage" refers to the common battery cage type of housing and "alternative systems" refers to non-cage systems such as aviaries, barn systems etc. The so-called "enriched cages" aim to give hens more freedom of movement and improve hen welfare by providing 'furniture' (*e.g.* laying nests, perches and dustbaths). In the literature the term "furnished cages" instead of "enriched cages" is also used. Both terms refer to the same type of system. The EU-Directive states that the "unenriched cage" (battery cage) will be phased-out by 2012.

The provisions of the 1999 EU-Directive are being progressively implemented since 2002. However, not all Member States of the EU have implemented the EU-Directive in the same way. Some countries have set more strict regulations. In particular, the speed in which unenriched systems will be phased out (*e.g.* Sweden, Germany), a ban on beak treatments (*e.g.* Sweden, Finland) or stricter regulations for certain systems (*e.g.* enriched cage in Germany).

Directive 1999/74/EC has encouraged technical changes in current systems. Not only have traditional battery cages been modified, but also new alternative systems (aviaries) have been developed. Many cage manufacturers have also developed new models of enriched cage systems and, although they all fall within the outline of the Directive, there is an ongoing need to evaluate the actual welfare status of hens in these systems including on commercial farms. The LayWel project, funded via the European Commission's Sixth Framework Programme and national funding from several EU countries, responded to these demands and studied the welfare implications of the different poultry farming systems. It also produced a method to estimate the welfare of laying hens in any kind of housing system. The project took into account pathological, zootechnical, physiological and ethological aspects.

The partners of the LayWel consortium covered much of the research that is going on in Europe in the field of housing and welfare of laying hens. The partners were from the following countries: Netherlands (coordinator), Denmark, France, Germany, Spain, Sweden and the United Kingdom and were represented by the authors of this paper.

The full project description, reports and other documents and information can be found on www.LayWel.eu. The information is also available on CDROM. Copies are freely available on request.

Objectives of the project

The general objective of the LayWel project was to produce an evaluation of the welfare of laying hens in various systems, with special focus on enriched cages, and to make the information well known, particularly in all member states of the EU and associated countries. The LayWel project was divided into seven Workpackages (WP), each of them focussing on a specific task in the project. Each WP produced one or more reports dealing with these tasks. The last WP had the task of combining the results of the preceding WPs and drawing overall conclusions.

WP1: LAYING HEN WELFARE: DEFINITION AND INDICATORS

Although several definitions of welfare have been published there is not always complete consensus between scientists as to what factors are relevant and how to measure welfare. In this WP various definitions of welfare were discussed, and the criteria needed to ensure valid measurements were analysed. A common starting point for the LayWel project was created by the agreed selection of parameters that are important for measuring welfare.

WP2: DESCRIPTION OF HOUSING SYSTEMS FOR LAYING HENS

WP2 focussed on the description and use of housing systems for laying hens. The EU-Directive defines three housing categories. However, it was felt that to determine the relation between welfare and housing, a more detailed categorisation was needed. WP2 therefore produced a detailed description of more categories of housing systems. These descriptions were agreed on by the partners and were used as basis for the evaluation of welfare of hens in various systems. Moreover, WP2 made an overview of the situation in Europe with regard to the use of housing systems and the number of hens housed in them.

WP3: HEALTH

The overall objective of WP3 was to generate, process and compile relevant data on the health (including mortality) of laying hens in enriched cages and alternative housing systems. An important part of this task was the co-ordination and documentation of a scoring system for bird health and welfare, including the condition of the integument. Another task of WP3 was the compilation of data on health traits and mortality from laboratory studies and commercial farms. This task was combined with similar tasks in WP4, 5 and 6, where data on behaviour, physiology and egg production were collected. For this purpose a lot of effort was invested in the design of a good database, that allowed all partners to contribute data in the same format and that enabled further analysis.

WP4: BEHAVIOUR

The overall objective of WP4 was to generate data concerning the needs, preferences, distribution, behaviour and use of facilities and enrichment components by laying hens. The housing system categories as described in WP2 were investigated regarding the way hens use the facilities available to them. As much of the current discussion was about the provision of litter, special emphasis was put on this aspect. Feather pecking is also a major issue and was therefore discussed in detail. To make the outcomes more generally applicable, various hybrids kept at different group sizes and stocking densities were studied.

WP5: PHYSIOLOGICAL STRESS INDICATORS

The aim of WP 5 was to find and formulate physiological parameters that give objective information on the actual stress levels of laying hens. A list of possible physiological parameters was made and the most appropriate ones were selected. Apart from defining the best physiological indicators, research also focussed on the question of whether birds in different housing systems have a different physiological responsiveness as a possible consequence of differences in stress.

WP6: PRODUCTIVITY AND EGG QUALITY

Productivity is not a very strong indicator of poultry welfare, as reduced welfare is not always immediately reflected in the production. In addition, good production is no guarantee of good welfare. Despite this, changes in production can give some insight into

welfare (*e.g.* early indications of disease, feed or water access problems), especially when combined with other measures, and are important for the economic viability of different systems. In addition, production parameters are daily and hence better documented by the farmer than most other parameters. The objective of WP6 was to describe the productivity and egg quality traits of laying hens in different production systems in relation to welfare. For this purpose a database was set up. As indicated above this database was also used to collect data for other WPs.

WP7: INTEGRATED WELFARE ASSESSMENT

The objective of WP7 was to integrate the information obtained from all preceding WPs to make an overall assessment of the impact of enriched cages and alternative housing systems on the welfare of the laying hen. This was done on two levels. Firstly, the welfare of laying hens in various systems was evaluated using recent data from the LayWel project and the literature and the pros and cons of each system were discussed. Secondly, a manual was produced as a self-assessment tool for farmers to enable them to evaluate welfare of their own hens. The manual covers all current husbandry systems and also gives guidelines for possible improvements in bird welfare.

Main results of the project

CHARACTERISATION AND USE OF SYSTEMS

Laying hens are housed in a variety of different systems. In Council Directive 1999/74/EC these systems have been categorised into 3 groups: alternative systems, unenriched cage systems and enriched cage systems. The category "alternative systems" comprises a wide variety of different types of system, ranging from very simple single level systems to multilevel aviaries with or without free-range facilities. For the purpose of the LayWel project this category was split into sub-categories.

A cage is considered here to be a system which is operated without the human carers entering it. This category was split into conventional cages and furnished cages. Conventional laying cages are usually small enclosures with welded wire mesh sloping floors. They provide equipment only for feeding, drinking, egg collection, manure removal, insertion and removal of hens, and claw shortening. These cages fall into the category of the EU-Directive "unenriched cage systems".

Furnished cages provide all the equipment found in conventional cages but in addition provide equipment intended to enable hens to express some of their behavioural priorities and needs. These extra elements may include perches, nest boxes, a litter area and extra height. These cages fall into the category of the EU-Directive "Enriched cages" if they are equipped with appropriate perches, suitable nest boxes and friable litter. The term 'furnished cages' is used in the remainder of this paper because it gives a more accurate description. For example, adding a perch or a nest to a cage can be factually described as furnishing it whereas it is a matter of (hen) opinion whether or not it enriches it. Furnished cages come into a wide variety of group sizes. If they house up to 10 -12 birds they are generally referred to as small group cages. At the moment larger cages may house up to 60 birds. It was decided that 15 to 30 birds could be regarded as medium sized groups and above this number they would be called large groups. Neither the maximum or optimum number of birds is yet defined.

The term "alternative systems" is often used to refer to systems which are not conventional cages or to any non-cage system. However, an "alternative" means one of several possibilities within a certain category. Hence each of the three categories of systems is an alternative system and the erroneous use of the word to refer to only one kind

of system should not be perpetuated in any future legislation. Therefore, all systems not being a conventional cage or a furnished cage will here be referred to as "non-cage systems".

The three types of system considered in the LayWel project are therefore conventional cage, furnished cage and non-cage. In *Table 1* a very brief specification is given of the different categories of housing systems as defined in the project as well as their acronyms used subsequently.

In recent years housing of laying hens has changed a lot in different countries in Europe. The proportion of hens housed in non-cage systems has increased during recent years. Countries with higher percentages include Austria, Denmark, Ireland, the Netherlands, Sweden and the United Kingdom. In other *e.g.* Italy and Spain the percentage remains very low. As regards furnished cages, Sweden has the largest proportion of the national flock with 40% in such systems (FCS).

DATABASE

In order to compile relevant data from diverse sources (*e.g.* laboratory studies and commercial trials) for further analyses and comparisons of different housing systems a database was set up. The design process of this database brought to light the difficulties in comparing data from different studies because variables measured, the time when they were measured and the techniques used turned out to be very study specific. Solutions were found to overcome these difficulties in order to include as much data as possible in the database. Two main data entry rounds were held to collect all the data from the eight different partners. The final database included eleven different topic worksheets (Data sources, General, Rearing housing, Laying housing, Management, Health/Exterior, Behaviour, Physiology, Production, Log, Acronyms), data from 230 different flocks and 459 lines of data. A data line comprised variables for a certain treatment, so data entered for a flock of birds could consist of several data lines covering the different treatment groups (*e.g.* different housing systems). The above categories describing different housing systems used in laying hen production were used as descriptors for the different studies. Most of the data came from replicated scientific studies that have been subjected to statistical analysis and verification.

Data included health traits and mortality, behavioural parameters, physiology and egg production. For some systems (*e.g.* FCL) there were relatively few data reported while others (*e.g.* FCS) were far better represented.

HEALTH AND MORTALITY

To allow comparison of results of trials done in different countries it was felt essential to standardise scoring systems for health and skin damage. Such a system should be easy to use by scorers of different background *e.g.* scientists, welfare inspectors, administrators, breeders and producer organisations. It should also provide a good general picture for the documentation of the status of integument and health of birds in research as well as in commercial production. Within LayWel, such a system was developed. The system includes plumage condition scores of 6 body parts (neck, breast, cloaca/vent, back, wings and tail), scores of pecking damage to skin of rear body and comb, and scores of bumble foot lesions. All items are scored between 1 (poor) and 4 (good). The system is clearly described with guidelines and photographically documented for white as well as for brown genotypes (see: www.laywel.eu or www.livsmedelssverige.org/hona/scoringsystem).

Among the main results from the LayWel study were the lower mortality and better plumage condition in beak trimmed birds than in non beak trimmed, especially for brown genotypes in NC systems (Tauson *et al.*, 1999). Using all the available data on mortality,

a model was produced with an R-Squared value of 0.55 (adjusted value 0.51). Some variables did not explain significant amounts of variation in bird mortality (*e.g.* rearing system) but there were five variables that were significantly associated with bird mortality. These were:

- **beak trimming** - significantly higher mortality in groups of non-beak trimmed hens ($F=21.5$, d.f. 1, 331; $p<0.0001$)
- **season** ($F=7.7$, d.f. 4, 331; $p<0.0001$). Birds placed in laying accommodation in the winter months had lower mortality than birds placed in laying accommodation at other times of year.
- **an interaction between housing system and whether the study of that housing system was conducted on commercial farms, experimental units or in a large-scale semi-commercial test facility** ($F=5.3$, d.f. 11, 331; $p<0.001$). It is interesting and important that there was no significant main effect of housing system, only an interaction with whether the system was run under truly commercial conditions or within a scientific institute. This suggests that differing management practices had just as big an impact on bird mortality as the housing systems themselves. The nature of the interaction is important. Mortality in conventional cages, single-tier systems, and furnished cages with medium or large groups was much greater under experimental conditions than under commercial or test-scale conditions. Mortality in multi-tier systems was not greatly affected by whether the conditions were commercial or experimental. In small-group furnished cages, the lowest mortality was found under test-scale conditions, with little difference between commercial and experimental conditions.
- **feather colour** ($F=5.0$, d.f. 3; 331; $p=0.002$) The analysis compared white, brown and hybrid birds, and studies that had housed a mixture of brown and white birds. Overall white-feathered genotypes appeared to show lower mortality than brown-feathered hens.
- **country** ($F=4.2$, d.f. 5, 331; $p=0.001$).

The significant effect of all these factors when included together in one model shows that they are all important. Thus, even though different countries studied different systems, genotypes and beak-trimming practices, residual differences between countries existed once these other explanatory variables had been included in the model. However, the degree of confounding within the data base makes interpretation of the results quite complex by simple examination of grouped means. It is well established both scientifically and from practical experience that beak trimming reduces mortality in general, which is why the practice came to be used. It might however be a peculiarity of the LayWel data that beak-trimmed white birds had an average 6% mortality, which was more than doubled in brown birds with intact beaks, as there was not an even distribution of the number of birds of each genotype across systems, nor of beak treatment. Other risk factors such as group size could be more relevant predictors of mortality, and this is indicated by significantly greater mortality with larger group size in furnished cages and in non-cage systems (*e.g.* Weitzenbürger *et al.*, 2005). This study also showed that floor rearing implied higher mortality for FCs than cage rearing. However, some recent evidence gathered since the LayWel data base was closed, from groups of 40 and 60 hens in large furnished cages in the UK suggests that such cages, if well designed and managed, can have good feathering and low mortality even with intact beaked hens (Elson and Croxall, 2006).

For the database as a whole, mortality attributed to feather pecking and/or cannibalism accounted for approximately one third of all mortality. This varied between housing

systems. Although there was no significant effect of rearing system on overall mortality, a more informal examination of the subset of data relating to subsequent mortality attributed to feather pecking and/or cannibalism in laying housing systems shows a possible relationship with rearing system, as shown in *Table 2*.

There were too few and highly variable data records to analyse these relationships formally but it would be informative if future studies could examine the consequences of rearing pullets in furnished cages if this was to be their housing system during lay. Indeed there is a pressing need both for new systematic experimental work on the design and influence of rearing systems on subsequent welfare of laying hens in all housing systems, and for all studies and commercial producers to record and monitor the impact of rearing systems.

Plumage condition was inferior in NC systems compared to in FCS on commercial farms with non beak trimmed birds of both genotypes. Modelling the data indicated the variable most strongly associated with plumage condition was the rearing system ($F=10.2$, d.f. 3; 207, $p<0.0001$), whereby birds reared in floor systems tended to have better plumage than birds reared in cages. The model showed that beak treatment did not have an effect on plumage, suggesting that beak trimming may have a stronger influence on reducing severe injurious pecking resulting in cannibalism than it does on the type of gentle feather pecking that may reduce plumage condition.

As regards foot condition - bumble foot syndrome - the NC systems were inferior to CCs and most often to the FCs. As with the incidence of keel bone deformities these defects are connected to the use of perches per se and/or improper design of these and of other places birds choose to roost on and is thus mainly present in systems other than CCs. The incidence of bumble foot is also linked to hygienic conditions in the system following contact with manure and moisture of the foot pads of birds combined with their long time perching.

Recent evidence suggests that a high proportion of birds sustain keel bone fractures during the laying period in all systems, as the high productivity of the modern laying hen is accompanied by bone fragility. The prevalence of fractures is further increased in non-cage systems (where over 60% of birds may be affected) due to the risk of collision with perches, nestboxes and other structures (Wilkins *et al.*, 2004; Nicol *et al.*, 2006). Reduced bone strength also results in a high level of fractures sustained during handling at the end of lay.

BEHAVIOUR

The prevalence of feather pecking in various production systems was evaluated on the basis of information from birds housed in commercial-scale systems (not very small experimental trials). This showed that feather pecking is still a very predominant welfare problem in commercial flocks in NC systems with a prevalence of between 40 and 80%. The prevalence of cannibalism is lower but up to 20% of flocks were affected in one survey and up to 40% in another. Hens kept in any of the four designs of furnished cage did not differ in the level of feather pecking or aggressive pecking. It was concluded that the presence of apparently purposeless behaviour or of high levels of aggression or redirected behaviours such as feather pecking and cannibalism are important bird-based indicators that can be used to evaluate housing systems with respect to bird welfare.

An overall review of the preferences of laying hens was published (Weeks and Nicol, 2006). This concluded that important behaviours include dustbathing, pecking and scratching behaviour (foraging). Substrate needs and preferences to perform these behaviours were studied and a ranking of the different substrates in terms of preference to perform the behaviour could be made. The value of a particular substrate varied with the behaviour performed in the substrate. There was for instance a strong preference for peat

moss for dustbathing. Through observation of the behaviours, important criteria were defined for assessing substrate quality. These criteria were used to evaluate litter quality in various housing systems in the second project year. As behavioural studies are time consuming and the budget was limited, two contrasting housing systems were chosen: furnished cages and single floor non-cage systems (or barn systems). Substrate in barn systems gave more opportunities for laying hens to perform dustbathing and foraging behaviour as compared to the substrate area in furnished cage systems. The low proportion of hens performing foraging behaviour and the absence of complete dustbaths in the furnished cage models used in the study indicates that the substrate areas in these systems do not fulfil the needs of the hens, confirming results of earlier studies in furnished cage systems (*e.g.* Olsson and Keeling, 2003). Big differences in use of this facility among individuals as well as genotypes during a full laying cycle may also indicate differences in needs for this facility among birds (Wall and Tauson, 1999). However, as FC models are continuously developed the substrate areas provide different designs, locations and areas which make the accessibility and attractiveness better for the birds (Tauson, 2005). New substrates, which may be more suitable, are also being brought into use *e.g.* laying hens dry mash feed.

For more information and references on behaviour see Kjaer *et al.* (2005).

PHYSIOLOGICAL STRESS

On the basis of ongoing stress and physiological studies in laying hens within the laboratories of the LayWel partners, different parameters were evaluated regarding their suitability as stress indicators. Corticosterone in plasma and faeces may be used, but heterophil-lymphocyte ratio (H/L) was also considered as a good stress indicator.

Research was conducted to see if birds in different housing systems differed in their physiological stress response, which would suggest that birds experienced different stress levels.

For this WP, data were compiled from 16 independent experiments, provided by five of LayWel's partners. As a consequence, the experiments differed in their scientific objectives but also in numerous other aspects, including rearing and housing conditions or densities, as well as the genotypes used. On the basis of these data it proved very difficult, if not impossible, to reach any firm conclusions. Depending upon the parameter chosen it could be concluded that welfare was improved, comparable or decreased in furnished cages or alternative systems compared to conventional cages. Despite these difficulties one cannot conclude that physiological indicators are not relevant to assess welfare. Indeed, it illustrates the risk of misinterpretation that can result by taking into account a single or a limited number of welfare indicators of the same category and/or to use conclusions from a single study or by concluding using only one genotype. This also reinforces the need to expand the database.

PRODUCTION AND EGG QUALITY

The production parameters overall, showed that production is less efficient in non-cage systems (*e.g.* higher feed conversion ratios). The results indicate however, that the performance of birds in the different types of furnished cages is not worse than that of those in conventional cages. Egg quality parameters, such as cracked and dirty eggs, showed that egg quality in furnished cages is dependent on cage design, and such problems can be avoided with good cage design (Wall and Tauson, 2002). The design of furnished cages has further improved recently and production parameters from these new models should be evaluated to get a more up-to-date picture of production in small, medium and large group furnished cages. This would require an extension to the data population and use of the LayWel database, as already proposed above.

The LayWel data on production parameters clearly illustrated the high use of the nest box for laying eggs by laying hens and therefore the high risk to welfare of hens in conventional cages when nesting is not possible. The high use of nest boxes (> 90%) indicates that laying hens place considerable value on laying eggs in a secluded area (Abrahamsson and Tauson, 1997; Van Niekerk and Reuvekamp, 1999; Tauson and Holm, 2002; Cooper and Albentosa, 2003). Use of the nest box may therefore be used as an indicator of welfare. If the use of the nest box is low (*e.g.* due to poor design) or decreases over time, the needs of the hens are not met.

It is further concluded that the main production parameters (feed and water parameters and egg production parameters) are not suitable as important indicators of welfare, but they should be monitored continuously and used as an indicator as they can be one of the first indicators of general welfare being or becoming impaired.

SELF ASSESSMENT TOOL

Within LayWel an on-farm auditing procedure was developed in the form of a manual for self-assessment. The manual consists of three parts. The first part explains what is meant by welfare and outlines the relevance of welfare assessment. It also summarises risks to welfare for key indicators in the main categories of housing system. The second part contains recording forms, with guidance for assessing hen welfare in the three main systems. These enable regular checks of a range of indicators of laying hen welfare to be carried out systematically. The indicators were chosen to be relevant to hen welfare as well as feasible and reliable to apply in practice. The suggested assessments can be performed relatively quickly without the need for training. Most of the forms indicate points at which action should be taken to improve welfare and give some suggestions for achieving this. Further background information in the final part can be expanded for local needs with for instance country-specific legislation, addresses etc.

INTEGRATED WELFARE ASSESSMENT

As the type of data did not often allow a formal statistical analysis the evaluation of welfare was a presentation of risk factors and advantages and disadvantages of various housing systems. Conclusions are that, with the exception of conventional cages, all systems have the potential to provide satisfactory welfare for laying hens. However this potential is not always realised in practice. Among the numerous explanations are management, climate, design, different responses by different genotypes and interacting effects. For example there was different use of nestboxes in furnished cages by different genotypes. The design of small furnished cages also had a significant impact on dustbath use.

All cage systems tend to provide a more hygienic environment with low risk of parasitic disease. On the basis of the LayWel data, a possible high risk of poor welfare on a flock basis was identified in all systems with larger group sizes (above approximately 10-15 birds) from damaging pecking and cannibalism. All laying hens are also at high risk from sustaining fractures both during the laying period and at depopulation (Wilkins *et al.*, 2004). There is evidence that both these problems are associated with genetic selection for high productivity. Some existing genotypes (mainly white feathered) show a lower tendency for damaging pecking. Much greater emphasis should be placed on selecting genotypes with reduced damaging feather pecking tendencies. Recent studies have shown that bone strength can be improved in laying hens by selection over only one or two generations without a great decrease in productivity (Fleming *et al.*, 2005, see also http://www2.defra.gov.uk/research/project_data/More.asp<I=AW1127&SCOPE=0&M=CFO&V=RI#Desc). For good laying hen welfare it is a priority that action be taken to reduce the current unacceptable level of fractures sustained during the laying period in all

systems apart from conventional cages. This is likely to involve a combined approach of selective breeding, plus refinements to design and management including lighting.

Conventional cages do not allow hens to fulfil behaviour priorities, preferences and needs for nesting, perching, foraging and dustbathing in particular. The severe spatial restriction may also lead to disuse osteoporosis. We believe these disadvantages outweigh the advantages of reduced parasitism, good hygiene and simpler management. The advantages can be matched by other systems that also enable a much fuller expression of normal behaviour. A reason for this decision is the fact that every individual hen is affected for the duration of the laying period by behavioural restriction. Most other advantages and disadvantages are much less certain and seldom affect all individuals to a similar degree. The assessment is summarised in *Table 3*.

Conclusions and recommendations

GENERAL

A major achievement of the LayWel project was the compilation of the database. Its structure and the collaborative discussions that led to it were extremely valuable, and will undoubtedly influence and improve the design of future scientific studies of laying hen welfare. It was very beneficial that LayWel partners representing seven countries, and with contacts in other EC countries, worked together on designing and contributing data to the database. This will ensure a much more unified approach in the future and could lead to more collaborative projects.

The carefully structured layout of the database enabled gaps in data availability to be clearly identified and indicated the type and format of data that future studies might collect. Additionally, future methodology is likely to be more uniform.

In order to produce statistically better valid models, more data are needed in most areas, but especially for some of the newer (furnished cage) systems and thus the database ought to be expanded at least until sufficient data are entered to enable this. Data from in excess of 100 treatments (flocks) are generally required for modelling and this quantity could potentially be gathered within three years for many parameters.

We recommend that:

- support is given to maintaining the database for at least 3 years so that future work may be included in it and so that data can be more reliably modelled
- all scientists studying laying hen welfare consider expanding the number of indicators used in future work so that individual studies measure a greater range of indices (*e.g.* including physiology and behaviour)
- more data are collected for areas of limited data availability (*e.g.* feather pecking in beak trimmed and non beak trimmed flocks in FCM and FCL).

INTEGUMENT SCORING

A second major achievement of the project was the development of feather scoring and integument (skin, head and feet) scoring systems together with comprehensive sets of photographs. This included developing methodology for transforming data from different scoring systems, which makes comparing different studies much easier.

We recommend that:

- the integument scoring systems are widely adopted, as they represent the consensus of the LayWel partners and an integration of several previous systems
- integument scoring is routinely and frequently carried out on all farms to assist in the detection of damaging pecking, which is currently a widespread welfare problem.

BEHAVIOUR

The most important enrichment for hens is the provision of a discrete, enclosed nest site. More scientific research is needed to determine whether perching is a behavioural need and the extent to which hens value dustbathing and need a substrate, but there is strong evidence that both are a behavioural priority. The presence of apparently purposeless behaviour or of high levels of aggression or redirected behaviours, such as feather pecking and cannibalism, are indicators that the housing system is not satisfactory for bird welfare.

Feather pecking and cannibalism are still very predominant welfare problems in commercial flocks in non cage systems.

In furnished cages about 40 to 50% of the hens perched during the day and 80 to 90% during the night. The use of perches at night was higher in the smaller compared to medium or larger furnished cages, which could be due to design differences. The use of the dustbathing area was very different for the LayWel data from four models of furnished cages. Birds reared on floor had a slightly higher dustbathing activity than cage reared birds.

We recommend that:

- more research is carried out to determine the influence of rearing system design on behaviour during lay and on the nature of and timing of provision of key resources such as foraging mediums, perches, nestboxes etc.
- all hens be provided with discrete, enclosed areas for egg laying
- perches are provided, and that more research and development is carried out to optimise their design and use by hens
- assessment of substrate quality in different laying hen housing systems should include recording of dustbathing behaviour activity and quality and foraging behaviour
- more research is carried out to determine optimum substrates for foraging and for dustbathing (in particular environmentally-friendly alternatives to peat (including laying hen dry mash feed), which is a preferred choice for dustbathing)
- more research is carried out to determine optimum design of dustbathing areas in furnished cages
- suitable genotypes with minimal tendencies for feather pecking are selected for use in group housing systems
- to study optimal group size in FCs.

HEALTH

We recommend that:

- both industry and research scientists direct maximum effort to establishing the causes of outbreaks of feather pecking and designing housing systems and management strategies to minimise this risk
- causes of the high levels of fractures during lay are determined together with strategies for reduction as a matter of priority
- hens are examined (and scored) for bumble foot regularly, but especially at 35-45 weeks of age.

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Table 1 Major housing categories with acronyms used and some specification.

Acronym	Description	Specification
CC	conventional cage	all cage systems that are not furnished
FC	furnished cage	cages with furnishment as required by EU-Directive 1999/74; no distinction in group size
FCS	small furnished cage	FC with up to 15 hens/cage
FCM	medium furnished cage	FC with 15-30 hens/cage
FCL	large furnished cage	FC with more than 30 hens/cage
NC	non-cage systems	all non-cage systems, e.g. barn, aviary, free range

Table 2 Effect of rearing system on mortality due to pecking or cannibalism in the main categories of housing system.

Average percentage mortality due to pecking/ cannibalism +/- s.dev Rearing system	Housing system conventional cage	furnished cage	Non cage
single floor	23.6 +/- 23.3	15.1 +/- 17.1	6.1 +/- 7.2
multi tier			3.8 +/- 3.5
cages	0.9 +/- 0.9	11.9 +/- 12.0	
single floor and multi tier			1.8 +/- 2.2
cages and single tier			6.0 +/- 6.2

Table 3 Risk to welfare for key indicators in different categories of housing system (simplified table, derived from LayWel results)
In most cases the ORANGE (actually mid grey - see footnote) areas indicate a variable risk

Indicator	Conventional cage	Furnished cage			Non-cage		Outdoor
		small	medium	large	single level	multi level	
Mortality (%)							
Mortality due to feather pecking and or cannibalism							
Red mite							
Bumble foot							
Feather loss							
Use of nest boxes							
Use of perches							
Foraging behaviour							
Dustbathing behaviour							
Air quality							
Water intake							

(Note, some very recent unpublished figures indicate low mortality is archievable in large furnished cages)

Key: risk of poor welfare = high, = medium/variable, = low, = unknown.

This table is intended as a 'traffic light' system; therefore assume RED for dark grey, ORANGE for mid grey and GREEN for light grey.