



**Opinion of the Scientific Panel on Animal Health and Welfare on a request from the Commission related to the welfare aspects of various systems of keeping laying hens**

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**(Question N° EFSA-Q-2003-092)**

**Adopted by the AHAW Panel on 10<sup>th</sup> and 11<sup>th</sup> November 2004**

**Chapter 4.8 on Food safety affected by different production systems (Microbiological and Chemical hazards) was jointly adopted by the BIOHAZ Panel on 21<sup>st</sup> October 2004 and the CONTAM Panel on 1<sup>st</sup> February 2005 respectively**

**SUMMARY OF OPINION**

EFSA was invited by the EU Commission to draw up an opinion on the welfare aspects of the various systems of keeping laying hens described in Council Directive 1999/74/EC and enriched cages in particular. The implications of these systems towards obtaining safe eggs for consumers were also to be considered.

This opinion was adopted by the Scientific Panel on Animal Health and Welfare (AHAW) on its Plenary Meeting held on 10<sup>th</sup> and 11<sup>th</sup> November 2004. The chapter on Food safety affected by different production systems (Microbiological and Chemical hazards) was jointly adopted by Scientific Panel on Biological Hazards (BIOHAZ) on 21<sup>st</sup> October 2004 and Scientific Panel on Contaminants in the Food Chain (CONTAM) on 1<sup>st</sup> February 2005 respectively.

According to the mandate of EFSA, ethical, socio-economic, cultural and religious aspects are outside the scope of this Opinion.

In the current Directive (1999/74/EC) the terminology for housing systems of laying hens is confusing. In order to be clear, throughout this opinion, the terminology "laying systems" is used to refer to those systems in use for the housing of adult egg laying hens instead of "rearing systems" (terminology used in the Directive) that is generally understood to refer to housing systems for the rearing/growing of hens from one day old until about 18 weeks of age when they are moved to the laying house. The term "alternative systems" is used in the Directive to refer to any non-cage system.

The term "alternative systems" is used in the Directive to refer to any non-cage system. In the industry the term is used to refer either to systems which are not conventional cages or to any non-cage system. A cage is considered here to be a system which is operated without the human keepers entering it. All other systems will therefore be referred to as "non-cage systems". The three categories of systems



for housing laying hens considered in this opinion are conventional cage systems, furnished cage systems (called enriched cage systems in EU Directive 1999/74/EC) and non-cage systems (called alternative systems in Directive 1999/74/EC).

Animal welfare science is a rapidly expanding area and there have been major methodological and conceptual advances in this area since the Scientific Veterinary Committee, Animal Welfare Section, published the "Report on the welfare of laying hens" in 1996. There has been increasing agreement that there are several useful methods which should be taken into account when assessing welfare. There advances in knowledge in hen welfare have included in particular behavioural priorities, prevalence of injuries, and pain perception. Animal health and physiology are still very important areas of research on animal welfare, but to these one can add the increasing role of neurobiology in basic animal welfare research and a striving after objective ways to integrate several different measures of animal welfare into a single overall estimate.

It is generally accepted that when assessing the welfare of animals in different housing systems and attempting to come to overall conclusions, the most trustworthy method is by combining measures from different disciplines and different approaches. It has been shown that despite diverse starting points there is often considerable agreement on key issues amongst experts.

The problem of how different indicators should be weighed against each other to come to a final conclusion as to whether or not the housing system promotes good bird health and satisfies the behavioural priorities of the bird is difficult, since there is still no generally accepted methodology for such integration of indicators. For this reason, conclusions and recommendations refer to pros and cons of the different laying systems, specifically referring to how the birds themselves may experience the various systems in which they are kept.

Research in the 1990s showed that welfare could be good in aviaries and other non-cage systems but that it was difficult to avoid outbreaks of injurious pecking without beak-trimming. Commercial experience has supported this position.

Recent research and development and commercial experience of systems have led to considerable improvements in design of systems, particularly furnished cages, and improvements in knowledge of how to manage birds in furnished cages and non-cage systems. These have solved some of the problems that existed at the time of the last report.

Housing systems for hens differ in the possibilities for hens to show species specific behaviours such as foraging, dust-bathing, perching and building or selecting a suitable nest. If hens can not perform such high priority behaviours, this may result in significant frustration, or deprivation or injury, which is detrimental to their welfare.

Injurious pecking is a serious problem in many systems and is especially difficult to control in large group furnished cages and in non-cage systems. The problem can be minimised by appropriate housing and management as well as genetic selection.

Beak-trimming is a painful procedure. At present, the least pain-inducing method of beak-trimming, involves very young birds.

Some of the most severe threats to bird welfare in the various systems are:

In Conventional Cages (CCs)

- Low bone strength and fractures sustained during depopulation.
- The inability to perform some high priority behaviours including nesting, perching, foraging and dust bathing.

In small Furnished Cages (FCs)

- Feather pecking and cannibalism in flocks with non beak trimmed birds
- Depending on lay-out some high priority behaviours (e.g. foraging, dust bathing) can not be performed or are limited.

In large Furnished Cages (FCs)

- No data available on relevant issues like bone fractures, feather pecking and cannibalism.

In Non-Cage systems (NCs)

- Bone fractures sustained during lay.
- Feather pecking and cannibalism in flocks with non beak trimmed birds.
- If an outdoor run is provided for birds in Non-Cage systems, there is additionally a high risk of parasitic diseases.

Hens should be provided with sufficient space to allow the movements described above to be carried out by each bird taking into account the presence of other birds and the frequencies of exercise and other activities required by the birds to avoid significant frustration, or deprivation or injury.

Injurious pecking should be minimised by appropriate housing and management as well as by genetic selection. Wherever possible, this should be achieved by provision for the hens' needs, including opportunities to avoid birds which carry out the pecking, rather than by beak-trimming. Any beak-trimming should be by the least pain-inducing method, and beak-trimming should be permitted only if significant amounts of injurious behaviour would otherwise result.

Keeping birds outdoors presents a risk of exposure to a greater range of infectious agents compared with birds kept only indoors due, for example, to exposure to wildlife including insect vectors. The possible consequences of exposure, infection and transmission, are likely to be different depending upon whether the birds are kept indoors or out, and the specific management systems. Where housing and

management conditions are poor, infectious agents, mainly bacterial, may have favourable conditions to develop and create chronic disorders for example respiratory problems.

The level of downgraded (grade B) eggs depends on the design and management of system. Although reported percentages of downgraded eggs and especially dirty, broken and cracked eggs, are often higher when laid in furnished cages and to a greater extent, in alternative systems, considerable improvements have been observed recently and further advances can be expected, especially in Furnished Cages.

In general, the level of bacterial eggshell contamination seems to be higher on eggs laid in Furnished Cages than in conventional cages. In alternative systems, this level is even higher and seems to be related mainly to a higher microbial load of the internal environment of the laying house.

There is limited information on the proportion of eggs contaminated and the level of contamination, with zoonotic bacteria, related to the methods of production. Of these, *Salmonella Enteritidis* dominates in eggs, raw egg materials and egg products, and can be present on the eggshell and in the yolk of eggs. In theory, the risk of contamination with *Salmonella* spp. and particularly with *Salmonella Enteritidis* might be higher when eggs are produced in some non-cage systems, because of the greater exposure of layers and their eggs to environmental contamination.

There are reports showing higher levels of dioxins and of dioxin-like PCBs for eggs produced in free range systems (including organic farming) than for eggs produced in cage systems. It is unlikely that contamination of animal feed is the origin of these higher levels, because EU feed regulation is equally applicable to all production systems. This implies that additional sources of contamination are present and special attention should be given to identify these sources of exposure.

**Key words:** Laying hens, welfare, diseases, conventional cages, furnished cages, non cage system, behavioural priorities (nest-building, drinking, feeding and foraging, dust bathing, preening, wing flapping, perching, feather pecking, cannibalism...)

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## 1. Background

Council Directive 1999/74/EC lays down minimum standards for the protection of laying hens and outlines in particular provisions applicable to ‘enriched cage systems, alternative (non cage) systems and unenriched cage systems’. The Directive provides that rearing of hens on unenriched cage systems shall be prohibited from 1 January 2012.

Article 10 of the Directive requires the Commission, not later than 1 January 2005, to submit to the Council a report, drawn up on the basis of a scientific opinion, regarding the various systems for keeping laying hens. The scientific opinion should take account of the pathological, zootechnical, physiological and ethological aspects of the various systems, and of their health and environmental impact.

## **2. Terms of reference**

In view of the above, the Commission requested the European Food Safety Authority to issue an opinion on the welfare aspects of the various systems of keeping laying hens.

This scientific opinion should in particular describe:

- The state of art regarding rearing and housing systems for laying hens, with special reference to those systems described in Council Directive 1999/74/EC and enriched cages in particular, and its impact in the animal health.
- The ability of these systems to satisfy the physiological and ethological needs of the animals and provide for good animal welfare and animal health and zootechnical aspects of these systems,
- The implications of these systems towards obtaining safe eggs for consumers.

The mandate was accepted by the Panel on Animal Health and Welfare (AHAW) at its Plenary Meeting, on 30<sup>th</sup> September and 1<sup>st</sup> October 2003. It was decided to establish a Working Group of AHAW experts (LHWG) chaired by one Panel member. Therefore the Plenary entrusted a Scientific Report to a working group under the Chairmanship of Dr H.J. Blokhuis. The members of the working group are listed at the end of this Opinion.

This opinion has been adopted at the Plenary Meeting of the AHAW Panel on the 10<sup>th</sup> and 11<sup>th</sup> of November of 2004 and the relevant conclusions and recommendations are based on the Scientific Report separately published on the EFSA web site (<http://www.efsa.eu.int>), which was drafted by the Working Group.

## **3. Scope of the opinion**

Throughout this opinion, the terminology “laying systems” is used to refer to those systems in use for the housing of adult egg laying hens (*Gallus gallus domesticus*)

instead of "rearing systems". The term rearing systems is generally understood to refer to housing systems for the rearing of hens during the growing period from one day old until about 18 weeks of age when they are moved to the laying house.

The term physiological need is mentioned in the mandate. Animals have needs which are satisfied by obtaining a resource or being able to carry out an action. Although the satisfying of needs may involve physiological or behavioural change in the animal, the need itself is not physiological or behavioural. Hence, in this opinion the word need will be used without these qualifiers. Whilst the Directive refers to ethological or behavioural needs, the term "behavioural priorities" will be used in this opinion to refer to activities that are important to an animal and, if denied, are detrimental to its welfare. Where the Directive refers to physiological needs, this was considered to refer to factors like nutrition, temperature, humidity and atmospheric ammonia and CO<sub>2</sub>. These factors can seriously affect welfare if they are not set and monitored correctly. However, the opinion starts from the premise that the management of the different laying systems is according to generally accepted good management practices, including care for proper nutrition and good climate conditions. Therefore, these factors will not be considered in the present opinion, except when they need particular attention in a specific laying system or if such a system has inherent difficulties related to these issues.

The term "alternative systems" is used in the industry to refer to systems which are not conventional cages or to any non-cage system. 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 this opinion or in any future legislation. A cage is considered here to be a system which is operated without the human keepers entering it. All other systems will therefore be referred to as "non-cage systems". As explained in the Scientific Report, a more accurate term for "enriched cage" is "furnished cage". The three types of system considered are therefore conventional cage (CC), furnished cage (FC) and non-cage (NC).

A full assessment of laying hen welfare in these three systems can be found in the Scientific Report separately published in the EFSA web site <http://www.efsa.eu.int> which was drafted by a Working Group established by the AHAW Panel. The scientific report is considered as the basis for the discussion to establish the conclusions and recommendations by the AHAW Panel, as expressed in this opinion.

#### **4. Conclusions and Recommendations**

According to the mandate of EFSA, ethical, socio-economic, cultural and religious aspects are outside the scope of this Opinion.

The Scientific Panel on Animal Health and Welfare concludes on the welfare aspects of various systems of keeping laying hens, and the Scientific Panel on Biological

Hazards (BIOHAZ) and the Scientific Panel on Contaminants in the Food Chain (CONTAM) conclude on the food safety affected by different production systems (Microbiological and Chemical hazards) as follows:

#### **4.1. GENERAL CONCLUSIONS AND RECOMMENDATIONS**

##### Conclusions

In the current Directive (1999/74/EC) the terminology for housing systems of laying hens is confusing.

Recent research and development and commercial experience have led to considerable improvements in design of systems, particularly FCs, and management of birds in FCs and NCs. These have solved or reduced some of the problems that existed at the time of the last report.

There have also been advances in the knowledge of welfare aspects of hen biology, in particular to behavioural priorities, prevalence of injuries, and pain perception.

##### Recommendations

In order to ensure clarity, the three categories of systems for housing laying hens should be called conventional cage systems (called unenriched cages in EU Directive 1999/74/EC), furnished cage systems (called enriched cage systems in EU Directive 1999/74/EC) and non-cage systems (called alternative systems in EU Directive 1999/74/EC).

#### **4.2. ANIMAL HEALTH AFFECTED BY SYSTEMS (CHAPTER 4 OF THE REPORT)**

##### Conclusions

Infectious diseases may appear in any housing system. The impact on bird welfare will vary among diseases.

Keeping birds outdoors presents a risk of exposure to a greater range of infectious agents compared with birds kept only indoors due, for example, to exposure to wildlife including insect vectors. This generally results in a different panorama of diseases. Probability of exposure will be influenced by management systems. Avian influenza is one example where migrating flocks of wild birds in certain regions may serve as a potential vector to birds kept outdoors. In addition flocks kept outdoors are more likely to be exposed to bacteria such as *Campylobacter spp* and certain parasites.

The possible consequences of exposure, infection and transmission, are likely to be different depending upon whether the birds are kept indoors or out, and the specific

management systems. Flocks kept with outside access usually have a lower stocking density, and immediate access to outside air. However, due to the exposure pattern indicated above, infection with *Campylobacter spp* and intestinal parasites is relatively more common, for intestinal parasites, especially when compared with caged birds. In contrast birds kept indoors, especially in NCs, are likely to have more frequent bird-to-bird contact due to a higher stocking density, plus an environment where pathogen density is likely to be increased. This is likely to lead to increased infection and transmission rates. Where housing and management conditions are poor, infectious agents, mainly bacterial, may have favourable conditions to develop and create chronic disorders for example respiratory problems.

Red mite is a serious and widespread welfare problem that is difficult to control at present (effective drugs have been withdrawn because of new regulations requiring declaration of minimum residual levels). Mites occur in all systems, but are more likely to reproduce and infest hens where there is poor hygiene, and in systems where there are many places for mites to survive.

Endoparasites are more likely to increase in systems where hens are in contact with their droppings.

Injurious pecking is a serious welfare problem. Despite considerable research and knowledge gained it remains difficult to control. Complex genotype-environment interactions make its occurrence unpredictable. Injurious pecking may spread more in a large flock of birds than in small groups and may lead to extensive tissue damage, cannibalism and mortality. Current methods that attempt to control this behaviour (e.g. beak trimming, dim light) also have welfare implications. There is some evidence that the risk decreases with increasing practical experience of the stockperson with that type of system.

Suffocation following piling-up can occur in NC systems but is relatively infrequent.

Injuries through trapping in equipment can occur in poorly designed systems.

Foot disorders such as bumble foot and overgrown claws can occur in laying hens. Bumble foot is almost only seen in systems with perches and, while the basic cause is still not clear, it is associated with poor hygiene, perch materials and design, as well as genotype. The use of abrasives for shortening and blunting claws is important especially in caged white hybrid hens.

A small proportion of laying hens exposed long-term to certain types of perch tend to develop deformation of the keel bone, although this may not be a welfare problem unless swollen *bursae* occur.

The prevalence of fractures sustained during the laying period appears, from limited evidence, to have increased dramatically in the past 10 years, and is high even in single level NC systems, where the risk of crashing would be expected to be low. It is

not known whether the prevalence of fractures sustained during the laying period has also increased in caged flocks, or what the prevalence in FCs and Multi-tier aviary systems might currently be.

Several studies have demonstrated that hens in FCs and NCs have significantly stronger bone strength than hens in CCs. Bone breakage, with associated pain and other poor welfare, during handling and depopulation is lower for NC than CC birds, despite an increased risk of impact during depopulation from NC systems. Nonetheless, bone breakage in NCs still occurs at an unacceptable level during lay and depopulation, suggesting that the increase in bone strength is insufficient. No information on the incidence of bone breakage is available for FCs.

The little available evidence suggests that heat stress is may be more serious in cages with high stocking densities than in NCs, although this has only been recorded in houses with inadequate climate control. Cold stress is far less important and depends mainly on the plumage condition.

Levels of airborne dust and micro-organisms in NCs are higher than in cages, because birds have access to large areas of litter. The limited information available suggests that high levels of dust can have detrimental consequences for hens' respiratory systems but such levels would seldom be reached in commercial NC housing systems.

Ammonia levels in NCs are usually higher than in cages. The limited information available suggests that high levels of ammonia can have detrimental consequences for hens' respiratory systems and eyes. Ammonia levels can however be reduced to a level that does not result in such health problems if appropriate control measures are taken.

Storage of manure inside the building is likely to result in high ammonia levels

Regardless of currently used housing systems, feather cover of laying hens usually deteriorates with age. Some studies have found that plumage condition is better in FCs compared with CCs. In serious cases the loss of feathers may be both a welfare and an economic problem. The causes of plumage deterioration are mainly two: feather pecking (e.g. in large group systems and non beak trimmed birds) and/or abrasion against equipment (e.g. in high density cages with wire mesh partitions).

Fatty liver syndrome is a production disease occasionally encountered in CCs. Since the 1996 report few new data has become available.

Although low mortality rates are possible in NCs, they are often higher and less predictable than in CCs, especially in certain genotypes and in hens with intact beaks. The most developed (i.e. best-designed) FCs seems to result in lower mortality compared with CCs and NCs.

## Recommendations

Measures should be taken to minimise disease challenge especially in free range birds.

Since pullets may become infested with parasites, e.g. red mite, during the rearing period, both farmers rearing pullets and egg producers should use good biosecurity measures to avoid the introduction and spread of parasites. To reduce the incidence of red mites equipment should be designed to minimise hiding places and facilitate control strategies.

The occurrence of disturbing events in or around the surroundings of the house especially in large flocks kept in NCs should be avoided. Equipment should be designed to minimise risks of injury.

In order to minimise bumble foot, good hygienic conditions should be provided on floors and on perches. The use of plastic or softwood materials with wide top surfaces in perches should be avoided. In order to control claw growth in cage systems, a durable claw abrasive material on the baffle plates fitted to the rear of feed troughs of cages should be used.

In order to minimise bone weakness, all systems for housing hens should provide sufficient space for walking, wing-flapping, and other activities necessary to maintain bone-strength and minimise risks of fracture.

Buildings in countries where hot conditions are frequently encountered should incorporate appropriate ventilation and cooling facilities. Greater attention should be paid to regular monitoring of climate conditions in the house and correct management of the ventilation and cooling.

Attention should be paid to the implementation of control measures to minimise dust, airborne micro-organisms and ammonia levels. Manure should not be stored in the air space in which housed birds are kept.

During both the laying period and depopulation, extreme care should be taken in handling hens to avoid bone breakages and associated welfare problems. Proper training, assessment of competence and supervision of staff handling hens should be implemented. Incentives that link proper handling to reduced fracture rate should be developed as a matter of urgency.

To ensure a low level of mortality, with special emphasis on low injurious pecking behaviour, further genetic selection of birds, especially those destined for NCs, is required.

Efforts should be made to minimise mortality and morbidity, including the use of benchmarking and other incentives, in order to reduce the risk of poor welfare. Only those systems, in which there is expected to be low mortality, should be used.

#### **4.3. PHYSIOLOGICAL INDICATORS AFFECTED BY SYSTEMS (CHAPTER 5 OF THE REPORT)**

##### Conclusions

Physiological stress indicators such as HPA activity and reactivity, H/L ratio and efficiency of the immune system function lead to results that are quantifiable but not always easy to collect and interpret.

The balance of evidence using these physiological indicators seems to indicate a better welfare for animals for instance at low density, when feather pecking and cannibalism are low and when hens are accustomed to human contact.

##### Recommendations

Physiological indicators should be interpreted in the light of other indicators of welfare (e.g. mortality, body damage, abnormal behaviour).

#### **4.4. PRODUCTIVITY RELATED TO SYSTEMS (CHAPTER 6 OF THE REPORT)**

##### Conclusions

Zootechnical parameters are not reliable indicators of welfare, but are useful early indicators to warn keepers of a possible welfare problem.

Productivity is potentially very high in modern hybrids and egg production can be prolific in most housing systems

##### Recommendation

Zootechnical parameters (e.g. water and feed consumption, egg production, egg shell quality) should be measured or monitored daily to alert producers to existing or impending welfare problems.

#### **4.5. BEHAVIOURAL PRIORITIES (CHAPTER 7 OF THE REPORT)**

##### Conclusions

Birds have a high behavioural priority to lay their eggs in a nest site that is suitable to them and to perform nest building behaviour. Their preference is for an enclosed nest and a pre-moulded or mouldable substrate.

Drinking, feeding, foraging and probably dust bathing are high priority behaviours for laying hens.

There have been no systematic studies carried out to establish the priority of preening, wing flapping and stretching although it is clearly established that each will occur as a rebound effect if it has previously been prevented by movement restriction in the housing condition. Data on the area used to carry out most normal activities exist.

Resting and perching are important aspects of birds' welfare. Roosting at night on an elevated perch is a behavioural priority. Perch design and hygiene are important to avoid damage to the foot pad and perch design is also important to minimise keel bone deformation.

All birds should be able to perch at the same time. For light hybrids and for some perch arrangements this may be possible at perch allocations as small as 12 cm per bird, but in medium hybrids or with other perch designs it may be necessary with 15 cm per bird.

The increased areas per bird in FCs that have been reported here (up to about 750cm<sup>2</sup>/hen) have been beneficial in allowing greater behavioural freedom without serious adverse damaging effects. In commercially available FCs, increasing minimum cage height from 38cm to 45cm had no effect on fearfulness or bird position within the cage, and only a minimal effect on behaviour in the usable area.

It is difficult to prescribe precise space allowances in NC systems due to the complexity of the environment and the ways birds distribute themselves.

Birds that have formed a social hierarchy prefer familiar to unfamiliar birds. Studies of social requirements have largely been done on brown beak trimmed hybrids. Studies in NCs have revealed no evidence that birds in larger groups attempt to form a social hierarchy, and so aggression levels are generally low.

#### Recommendations

Suitable nests, adequately distributed, should be provided in housing systems for laying hens.

In addition to providing feed and water, facilities for foraging should be provided. In order to increase foraging behaviour and to reduce feather pecking, it is recommended that chicks have access to litter during rearing. In the absence of

results specifying exactly how soon chicks should get access to litter in order for these beneficial effects of early access to litter to have effect, based on the precautionary principle it is recommended that litter be available from day 1.

On the basis of limited research results, sham dust-bathing does not seem to satisfy dust-bathing motivation and so litter for dust-bathing should be provided.

Steps should be taken during rearing (e.g. positioning of perches and feed and water) to ensure that all birds are able to move easily between the floor and perches or raised platforms.

#### **4.6. THE ABILITY OF SYSTEMS TO SATISFY BEHAVIOURAL PRIORITIES (CH. 8 OF THE REPORT)**

##### Conclusions

Although nests are well used, for some systems there is not enough information to conclude whether they fully satisfy the nest-building or selection behaviour motivation of the birds. NCs contain a greater variety of potential nest sites and elicit less frustration behaviour than systems with inadequate egg-laying facilities.

Feeding and drinking are behavioural priorities that are adequately catered for in all systems. Foraging facilities are well provided for in most NCs, and to a lesser extent in the larger FCs: they are not provided for in CCs.

There is not enough information to conclude whether or not some systems fully satisfy the dust-bathing behaviour motivation of all birds. CCs probably do not satisfy dust-bathing motivation and the risk of deprivation or frustration is greater in some current designs of FCs than in NCs.

To our knowledge, there have been no experimental studies comparing the possibilities for preening, wing flapping and stretching in different housing systems. Clearly, because of spatial restrictions, wing flapping will be prevented in CCs and may be hampered in the smaller types of FCs.

Perches are well used in FCs and NCs when they are well designed and positioned. High perches are preferred.

An increase in space from 450 to 750cm<sup>2</sup> per bird (as required by the EU Directive for FCs) appears to be beneficial for welfare, allowing a wider behavioural repertoire with no adverse effects on feather pecking, cannibalism, or aggression. However, the behavioural repertoire is still restricted compared with birds in NCs.

There are a few reported adverse effects of increasing group size in FCs. Other studies, and increasing field experience, with beak trimmed birds, suggest that group sizes of up to 60 birds or more can work well.

Behavioural repertoire is generally broader in NCs than in cages. Most birds seem to adapt to large flock sizes and there is no consistent body of evidence to suggest that flock size should be limited. There is also no evidence to suggest that increased stocking density per se has adverse effects on bird behaviour over the range 7-12 birds per m<sup>2</sup> if the hens are beak trimmed.

There appears to be variation in the welfare of individual birds within systems. In some flocks, especially in NCs, a small sub population, probably of extremely low ranked individual birds, seems to have extreme difficulties in accessing resources due to the behaviour of other birds.

There is a much greater risk of poor welfare due to injurious pecking and cannibalism in NCs and possibly large group FCs if birds are not beak trimmed.

#### Recommendations

Housing systems should provide the possibility for hens to carry out activities which are behavioural priorities.

An adequate number of discrete enclosed individual or group nests should be provided.

They should be placed so that birds can easily gain access to them. The ability to access nests may be affected by rearing and if the nests are raised off the ground then birds should be reared so that they learn to jump up to them.

Nest box use should be managed to minimise competition, be accessible easily and be positioned optimally.

Litter appropriate for foraging and dust-bathing should be provided in all systems and should be managed in such a way that it is friable and is readily accessible to all birds.

Perch material, design and position should be an important consideration when selecting a housing system for laying hens. Perches should be raised above the level of the floor.

There is some research that birds on elevated perches are less fearful and, given a choice, birds prefer the highest perch. But it is not known how high a perch needs to be elevated above the surrounding area to be perceived as satisfying, although it is unlikely that the whole area of a raised platform acts like a perch to birds.

Pullets should have access to elevated perches and raised platforms of suitable material and design, from an early age so that they are better able to use them when they are subsequently housed in NCs.

#### 4.7. AREAS OF CONCERN/MANAGEMENT OF PROBLEMS (CHAPTER 9 OF THE REPORT)

##### Conclusions

In order to minimise welfare problems associated with injurious feather pecking and cannibalism, the most practical way forward seems to be the genetic selection of birds that show a lower propensity for injurious pecking in present and future housing conditions and the consistent application of available knowledge about risk factors and preventive measures.

Beak trimming remains a widespread practice in many countries. Hot-blade trimming of young chicks continues to be the most widely used method but is known to cause pain. Laser methods are under development and may cause less pain than hot blade trimming. Infrared treatment is effective and is being used in hatcheries for day old chicks on an increasing scale. Information is lacking on, the immediate and longer-term effects of the mutilation involved in each of these methods, in terms of pain at the time of operation and pain and discomfort for subsequent days or weeks are not fully understood and may or may not be acceptable. Beak-trimming affects welfare by its effects on sensory receptors in the beak, or on abilities to use the beak.

Other beak treatments e.g. blunting by abrasives, are being developed and their effect on welfare as well as their efficiency as an intervention to minimise injurious pecking on a commercial scale has still to be tested.

Cannibalism is a serious multi-factorial unpredictable welfare problem. When an outbreak occurs it is difficult to control and often results in high mortality. If it occurs it usually affects more birds and has more severe consequences in NCs, especially in hens with intact beaks.

##### Recommendations

Genetic selection programmes should be implemented as a matter of urgency to minimise the risk of injurious pecking.

Beak trimming should be phased out, but only when suffering caused by cannibalism does not exceed that of the effects of the operation. Beak treatment methods and knowledge about best age of application should continue to be developed and improved. Their application should be controlled by codes of good practice.

Birds should be given opportunities for foraging in attractive litter and feed should be provided as mash or small particles rather than pellets.

Effective ways should be used to provide scientifically based modern advice to keepers, so that they are aware of all risk factors and so that current knowledge on how to reduce injurious pecking can be more widely implemented in practice.

#### 4.8. FOOD SAFETY AFFECTED BY DIFFERENT PRODUCTION SYSTEMS (CH. 10 OF THE REPORT)

##### 4.8.1. Microbiological Hazards

###### Conclusions

The level of downgraded (grade B) eggs depends on the design and management of system. Although reported percentages of downgraded eggs and especially dirty, broken and cracked eggs, are often higher when laid in FCs and to a greater extent, in alternative systems, considerable improvements have been observed recently and further advances can be expected, especially in FCs.

In general, the level of bacterial eggshell contamination seems to be higher on eggs laid in FCs than in CCs. In alternative systems, this level is even higher and seems to be related mainly to a higher microbial load of the internal environment of the laying house.

*S. Enteritidis* is the main concern in eggs. This serovar dominates in eggs, raw egg materials and egg products, can be present, at the farm level, on the eggshell and in the yolk of eggs and is mainly associated with the consumption of eggs and egg products. In the EU, *Salmonella Enteritidis* caused 65.7% of all notified human cases of salmonellosis. According to the present knowledge the prevalence of *S. Enteritidis* in eggs is low in many countries. .

A recent study (FSA, 2004) did not find significant differences in *Salmonella* spp contamination on the shell at retail level among eggs produced either in cages, deep litter, free range or organic systems, despite the very large numbers of samples that were tested, due to the known low prevalence. However, the likelihood of contamination of eggs with *Salmonella* spp. and particularly with *Salmonella Enteritidis* might be expected to be higher when eggs are produced in some alternative systems, because of the greater exposure of layers and their eggs to environmental contamination.

Keeping birds in systems other than CCs, especially alternative systems, may increase the demand for egg washing practices, due to the probable higher numbers of dirty eggs. An opinion on washing of eggs is being developed by the EFSA BIOHAZ Panel and it will be published in 2005. In addition, the EFSA BIOHAZ Panel has recently adopted an opinion on the use of vaccines to control *Salmonella* in poultry.

###### Recommendations

Changes or improvements in designs of systems should also be assessed in regard to the effects of egg quality on the microbial safety of eggs.

Special attention should be given to biosecurity measures.

Collection of monitoring data on the surveillance of zoonotic bacteria and especially *Salmonella* spp, should be improved including the origin and mode of production of eggs and egg products.

#### 4.8.2. Chemical Hazards

##### Conclusions

There are reports showing higher levels of dioxins and of dioxin-like PCBs for eggs produced in free range systems (including organic farming) than for eggs produced in cage systems. It is unlikely that contamination of animal feed is the origin of these higher levels, because EU feed regulation is equally applicable to all production systems. This implies that additional sources of contamination (e.g. soil, beddings produced from treated wood or local emission sources) are present.

##### Recommendations

Because exposure from various sources might have an impact on the contaminant level in eggs produced in free range systems, special attention should be given to identify these sources of exposure.

## 5. Future research

### 5.1. FIRST PRIORITY TOPICS

#### 5.1.1. Health and disease

New, effective and feasible treatment measures for the control of endo- and ectoparasites need urgent development, and the risk of the spread of infectious agents by wild birds and rodents should be further assessed.

Further research is needed to establish why problems of bone fragility and breakage are high even when good design principles are met. Better methods of detection of fractures in laying hens are required. There is also an urgent need to establish the causes of fractures sustained during the laying period

#### 5.1.2. Behaviour and systems design

##### 5.1.2.1. Injurious pecking and cannibalism

Fundamental studies of the underlying causes for why particular birds start to show cannibalistic behaviour would help improve our understanding.

As there is a genetic component, studies should be carried out to investigate the possible link between cannibalistic behaviour and commercially important traits, with a view to possibly implementing stronger genetic selection against this behaviour. Also selection against the damaging effects of pecking (e.g. selection to alter beak shape and sharpness) should be studied.

#### 5.1.2.2. Foraging

Studies should be carried out to more clearly define availability, qualities and amounts of foraging facilities appropriate to good welfare during rearing and laying periods.

#### 5.1.2.3. Comfort behaviour

Studies should be carried out to more clearly define the qualities (including feasible materials) and space allowances of facilities required to satisfy dust-bathing motivation.

#### 5.1.2.4. Rearing

Research is needed on understanding the impact of how birds are reared on their ability to function well in different systems later in life.

#### 5.1.2.5. Design

The development of FCs and NCs is ongoing. For this reason future research should focus on:

- Provision and use of litter and occupational devices
- Space requirements, group size and stocking density (e.g. larger type FCs with 60 bird colonies)
- Lighting

## 5.2. OTHER RELEVANT TOPICS

### 5.2.1. Health and disease

Research should be carried out on beneficial effects on health (e.g. respiratory disease) of access to an outside area.

Information is needed on large scale about the prevalence of old fractures in laying hens housed in all systems across the EU.

Research is required to examine the impact of methods of depopulation on fractures (i.e. by examination immediately before the slaughter process).

Studies are required to establish the connection between feather pecking, cannibalism, cloacal pecking and infectious disease e.g. salpingitis.

## 5.2.2. Behaviour and systems design

### 5.2.2.1. Egg laying

More research is required on nesting motivation in social situations. Studies should be carried out to determine whether nest building behaviour in the absence of loose material satisfies the behavioural priority for nest building.

Studies should be carried out to determine whether some birds do not lay eggs in the nests provided because they have a lower nesting motivation or because the nest is perceived as inadequate.

### 5.2.2.2. Comfort behaviour

More basic research is needed on whether or not sham dust-bathing satisfies the bird's dust-bathing motivation. Studies should be carried out on individual variation in dust-bathing motivation in different substrates and how this may be affected by rearing conditions.

Studies are needed on the design, location and management of the dust bath in FCs of all sizes. Studies are necessary to determine to what extent these behaviours are prevented in different systems.

Further research investigating preening, wing flapping and stretching are necessary so as to ensure that a potentially important aspect of laying hen welfare is not overlooked

### 5.2.2.3. Perching

Studies should be carried out to improve our understanding of how chicks learn to use perches.

More work is required on perch design, minimum height above the surrounding area for the perch to be perceived as a safe place for a roosting bird, and positioning in different systems.

### 5.2.2.4. Space, group size

Relative preference for space versus group size needs to be tested within the context of FCs, using appropriate group sizes.

In large groups investigations should be carried out to establish whether all conspecifics are perceived as familiar or unfamiliar or that there are any other potential causes of social stress.

Motivational studies are needed for behaviours requiring more space than 750 cm<sup>2</sup>.

To prevent persecution of sub-populations of birds further research is needed.

#### 5.2.2.5. Genetics

Criteria and methods should be identified and developed for genetic selection of birds that are better adapted to the systems.

#### 5.2.2.6. Depopulation

A full evaluation of the effects of depopulation from different systems on bird fearfulness should be carried out.

#### 5.2.2.7. Climate

Heat stress should be studied in FCs and NC systems at various stocking densities in houses with good climate control.

Research is required to determine the maximum acceptable levels of dust (total and respiratory) for laying hens. It should include studies on methods of minimising dust levels, especially those with small particle size.

Research should be carried out to determine the maximum acceptable levels of ammonia for laying hens. It should include ways to minimise ammonia levels, especially in NC.

#### 5.2.2.8. Physiology

Further research is needed to optimise objective indicators such as antibody production level following a challenge or cellular immunity performances.

Further development of non invasive techniques such as validation of assays of corticosterone in faeces and egg-white is required.

#### 5.2.2.9. Beak trimming

Research is required to determine the degree of immediate and lasting pain due to various methods of beak trimming applied at different ages. The effectiveness of beak blunting by abrasives in applied situations should be studied further.



### 5.3. FOOD SAFETY AFFECTED BY DIFFERENT PRODUCTION SYSTEMS

#### 5.3.1. Microbiological hazards

Research to improve FCs and NCs is required in order to ensure egg quality in relation to egg safety and to promote scientific evaluation of commercial designs.

Quantitative and qualitative studies should be conducted on the microbiology of eggs produced in different housing systems. The effects of such microbial load and types of bacteria on the processing technology and quality of further processed products should be studied.

### 6. Documentation provided to EFSA

No documents were provided by the Commission

### 7. References

The list of scientific publications can be found in the Scientific Report drafted by the working group and published in the EFSA website (<http://www.efsa.eu.int>)

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**European Food Safety Authority - AHAW**

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Annex to *The EFSA Journal* (2005) 197, 1-23; The welfare aspects of various systems of keeping laying hens

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## **SCIENTIFIC REPORT**

“Welfare aspects of various systems for keeping laying hens”

EFSA-Q-2003-92

Accepted by the AHAW Panel on 14<sup>th</sup> and 15<sup>th</sup> September 2004

Chapter 10 on Food safety affected by different production systems (Microbiological and Chemical hazards) was jointly adopted by the BIOHAZ Panel on 21<sup>st</sup> October 2004 and the CONTAM Panel on 1<sup>st</sup> February 2005, respectively

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## **TERMS OF REFERENCE**

### **1.1. Background**

Council Directive 1999/74/EC<sup>1</sup> lays down minimum standards for the protection of laying hens and outlines in particular provisions applicable to "enriched cage systems, alternative rearing systems and unenriched cage systems". The Directive provides that unenriched cage systems shall be prohibited from 1<sup>st</sup> January 2012.

Article 10 of the Directive requires the Commission to submit to the Council a report, drawn up on the basis of a scientific opinion, regarding the various systems of keeping laying hens. The scientific opinion should take account of pathological, zootechnical, physiological and ethological aspects related to this issue.

In view of the above, the Commission required the European Food Safety Authority to issue a scientific opinion on the welfare aspects of systems of rearing laying hens. The Authority was asked in particular to address housing infrastructure such as feeders, drinkers, perches, nests, provision of litter, access to open runs as well as space allowances per hen. The opinion also had to make reference to the implications of these systems towards obtaining safe eggs for consumers.

### **1.2. Mandate**

In view of the above, the Commission requested the European Food Safety Authority to issue an opinion on the welfare aspects of the various systems of rearing laying hens.

This scientific opinion should in particular describe:

- The state of art regarding rearing and housing systems for laying hens, with special reference to those systems described in Council Directive 1999/74/EC<sup>1</sup> and enriched cages in particular
- The ability of these systems to satisfy the physiological and ethological needs of the animals and provide for good animal welfare and animal health, and zootechnical aspects of these systems,
- The implications of these systems towards obtaining safe eggs for consumers.

Due to its scope, which would require input from more than one Panel, EFSA addressed this mandate to the AHAW Panel, concerning its main aspects of animal health and welfare, and the BIOHAZ and CONTAM panels concerning the Food Safety aspects.

At its Plenary Meeting on 21<sup>st</sup> May 2003, the Panel on Animal Health and Welfare (AHAW) accepted the mandate. A Working Group of AHAW experts on laying hens (LHWG) was set up under the Chairmanship of AHAW Panel member, Professor H.J. Blokhuis, with as a remit, the production of a Scientific Report. A member of the BIOHAZ Panel also participated in this working group. The Group's members are listed at the end of this report.

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<sup>1</sup> Official Journal L 203 , 03/08/1999 P. 0053 - 0057

### 1.3. Scope of Report

This Scientific Report provides the basis for the discussion which would establish the Scientific Opinion (conclusions and recommendations) to be produced by the AHAW, BIOHAZ and CONTAM Panels.

The chapter on food safety affected by different productions systems includes the microbiological and chemical aspects drafted by the working group and adopted by the BIOHAZ and the CONTAM Panel respectively.

The AHAW Panel accepted the Scientific Report drafted by the Laying Hens Working Group on the Plenary Meeting held on 14<sup>th</sup> and 15<sup>th</sup> September 2004. Chapter 10 on food safety affected by different productions systems (Microbiological and Chemical hazards) was jointly adopted by the BIOHAZ Panel on 21<sup>st</sup> October 2004 and the CONTAM Panel on 1<sup>st</sup> February 2005, respectively.

Throughout this report, the terminology “laying systems” is used to refer to those systems in use for the housing of adult egg laying hens (*Gallus domesticus*) instead of “rearing systems” that is generally understood to refer to housing systems for the rearing/growing of hens from one day old until about 18 weeks of age when they are moved to the laying house.

The term physiological need is mentioned in the mandate. Animals have needs which are satisfied by obtaining a resource or being able to carry out an action. Although satisfying of needs may involve physiological or behavioural change in the animal, the need itself is not physiological or behavioural. Hence, in this report the word need will be used without these qualifications. Whilst the Directive refers to ethological or behavioural needs, the term “behavioural priorities” (Cooper and Albertosa 2003) will be used in this report to refer to activities that are important to an animal and, if denied, are detrimental to its welfare. Where the Directive refers to physiological needs, this was considered to refer to factors like nutrition, temperature, humidity and atmospheric ammonia. These factors can seriously affect welfare if they are not set and monitored correctly. However, the report starts from the premise that the management of the different laying systems is according to generally accepted good management practices, including care for proper nutrition and good climate conditions. Therefore, these factors will not be considered in the present report, except when they need particular attention in a specific laying system or if such a system has inherent difficulties related to these issues.

Physiological indicators of welfare are specifically addressed in Chapter 2 and are also used to assess welfare in different laying systems.

The present report updates the “Report on the welfare of laying hens” of the Scientific Veterinary Committee, Animal Welfare Section, published in 1996 (SVC/EC, 1996), with the latest scientific knowledge. It evaluates the welfare of the birds using behavioural, physiological and health parameters and food safety aspects of the different laying systems. The present report does not consider labour, environmental impact and economic issues related to the different laying systems.

It was noted that the design and management of systems other than conventional cages, in particular aviary systems and furnished cages, have developed rapidly over

the last decade and are still being improved. Consequently, the performance of laying hens in these systems continues to improve in respect of not only egg production and product quality but also the welfare of the hens including their behaviour and health. These changes should be taken into account when evaluating reports in the scientific literature on systems which have subsequently been improved.

This report first considers recent thinking on the concept of welfare and indicators of welfare. Then, different systems for laying hens are categorised and described. The following chapters report on health and zootechnical parameters (as far as relevant to the welfare of the birds) as affected by systems and on behavioural priorities of the birds and the ability of systems to satisfy these. Separate chapters consider specific welfare concerns and food safety related to specific systems. In the final chapter a comparative welfare assessment is made.

## **2. ANIMAL WELFARE**

### **2.1. Animal welfare concept**

Animal welfare science is a rapidly expanding area and there have been major methodological and conceptual advances in this area since the previous report was written in 1996 (SVC/EC 1996). These can be summarised briefly as involving a decreasing emphasis on finding a single definition of animal welfare and increasing agreement that there are several ways of addressing the concept. In addition, in the past years there has been an improvement in the methods used for studying behaviour, especially motivation, and an increased interest in the role of animal cognition in animal welfare. Animal health and physiology are still very important areas of research on animal welfare, but to these one can add the increasing role of neurobiology in basic animal welfare research and a striving after objective ways to integrate several different measures of animal welfare into a single overall estimate.

This short introduction to the concept of animal welfare will present an overview of current research approaches and set the scene for the welfare indicators that will be used to assess laying hen welfare in this report and the process by which overall conclusions about bird welfare in the different laying systems are made.

There is an increasing consensus that the welfare of an animal can be approached in three main ways. One is to consider whether the biological systems of an animal are functioning in a normal and satisfactory manner. A second approach emphasises the subjective feelings of animals, proposing that animal welfare should be defined only in terms of what the animal actually experiences. The third approach is that animals should be able to perform their full behavioural repertoire, or at least have the freedom to perform most types of natural behaviour. These approaches are explained more fully in chapter 2 of a book on animal welfare (Appleby and Hughes, 1997). Classifying animal welfare in this way is not to say that these approaches are mutually exclusive, and indeed they have several points in common, depending on how precisely or how broadly each approach is presented. For example, feelings in animals will have evolved in the same way as any other biological system and the natural behaviour would, under normal circumstances, maximise biological

functioning. Referring back to the list of definitions given in the previous report, then some definitions of animal welfare may be related to a single approach, e.g. animal welfare is dependent on what animals feel (Duncan, 1993, 1996) whereas others may reflect more than one approach e.g. the welfare of an animal is its state regarding its attempts to cope with the environment (Broom, 1996).

The approach or concept of animal welfare that is preferred by individual researchers will inevitably influence the type of research they carry out, but it is still generally accepted that when assessing the welfare of animals in different housing systems and attempting to come to overall conclusions, the most trustworthy method is by combining measures from different disciplines and different approaches. This has been achieved using Delphi methodology (Anonymous, 2001) and it showed that despite diverse starting points there is often considerable agreement on key issues between experts.

In the previous report, indicators of animal welfare were classified as health, physiological, behavioural and production zootechnical (also called production) indicators and this report uses this same classification. However, in this current report, the focus is only on those indicators directly linked to bird welfare. The problem of how different indicators should be weighed against each other to come to a final conclusion of whether or not the housing system promotes a good bird health and satisfies the behavioural priorities of the bird is difficult, as it was in the previous report, since there is still no generally accepted methodology for such integration of indicators. For this reason, there are specific conclusions at the end of the sections and the table in chapter 11 summarises the overall risk to welfare in the different systems. Throughout the text, when alternative interpretations can be made from the same scientific data depending on which approach to animal welfare is taken, we have commented upon that. It has been our aim in this report to take a balanced approach by presenting all the available information relevant to animal welfare. We have however, been especially concerned about how the birds themselves may experience the various systems in which they are kept.

## **2.2. Behavioural indicators**

The previous report listed three main types of ethological study that could provide information about animal welfare. These were (i) comparison between behaviour in a natural or ideal environment, and behaviour in the environment under investigation (ii) determination of animals' own needs and priorities (iii) identification of signs of poor coping in experimental situations, and detection of these signs in the environment under investigation.

(i) Few new studies of wild or feral chickens have been conducted since the previous report. The information provided by such studies can provide the basis for testable hypotheses, but it does not, by itself, tell us much about the welfare of a hen (Cooper and Albertosa, 2003). Not all 'natural' behaviours need to be performed (Dawkins, 2003).

(ii) The second approach is thought by many to be the most powerful way of determining animals' needs, but it is also subject to difficulties of experimental design and interpretation of results. Considerable theoretical advances that bear on these

issues have been made since the last report. The 'behavioural priorities' approach argues that animals are able to perform their own integration of inputs and make sensitive judgements about their own best interests. This rationale has underpinned the continued use of preference tests, measures of demand and the self-selection of medication (e.g. analgesia).

The simple approach of assessing 'what hens want' by offering them a choice of alternatives in a laboratory setting has proved rather too simplistic. It can be useful for assessing relative preferences between, for example, substrate types (Sanotra et al., 1995) but provides little information on behavioural priorities (Nicol, 1997).

Behavioural priorities can be assessed by measuring motivational strength using consumer demand techniques. Work in this area has developed increasing scientific credibility and has been published in high impact scientific journals (Mason et al., 2001). Measuring price elasticity can assess priorities in many circumstances (Kirkden et al., 2003) the change in demand observed when the cost per unit consumption is raised. Such studies have been used to assess demand for resources such as nest boxes (Cooper and Appleby, 2003) and perches (Olsson et al., 2002 a,b) for laying hens. Other measures of behavioural priority such as consumer surplus or maximum price paid can also be derived from consumer demand experiments.

When conducting work on behavioural priorities it is essential to ensure that animals are offered choices with which they are cognitively and perceptually equipped to deal. There is evidence that preferences can be influenced by whether or not the animal can see the resource it is working to obtain (Warburton and Mason, 2003). Increasing research on the perceptual and cognitive abilities of the domestic fowl provides supportive evidence that chickens are able to make rational choices. Experiments have shown, for example, that chickens are able to 'plan ahead' and forego a small immediate reward in order to obtain a delayed but larger reward (Abeyesinghe et al. 2004). It is also known that chickens have some object 'permanence' ability. They are able to appreciate that an object still exists, even when it has moved out of sight (Freire et al., 2004). This background work gives us confidence that their choices in experimental situations involve integration of information about possible outcomes, and are not simply instinctive reactions to immediate stimuli.

Because the outcome of preference and consumer demand tests depends so much on factors such as the animals' previous experiences, the precise choices they are offered and the context in which they are offered, there is an increasing need to develop methods of assessing choices in real and relevant farming or commercial environments (Dawkins, 2003). This is now being done for laying hens, where choices can be assessed within commercial furnished cages (e.g. Albentosa and Cooper, 2003).

(iii) Assessing behavioural priorities using consumer demand techniques cannot answer all questions about animal welfare. In particular, it is not possible to determine whether an animal will 'miss' a resource that it has never experienced. Consumer demand methodologies rely on the animal gaining some experience of the resource that they are working for, either during training or testing (Cooper and

Albentosa, 2003). Attempts have been made to assess how hard deprived animals will work to perform searching behaviour, but it is difficult to demonstrate unequivocally that the animals have a specific representation of a resource goal (Nicol and Guilford, 1991; Freire and Nicol 1999).

For this reason, it is important that work on behavioural priorities is complemented by studies of behavioural indicators of poor coping. Various behaviours are observed in laying hens that indicate states of fearfulness, aggression, frustration and deprivation.

### **2.2.1. Fearfulness**

Indicators of fearfulness are commonly observed, as birds crouch, run or fly in response to perceived threats. Fearfulness has also been assessed experimentally using a variety of validated tests, including the duration of tonic immobility (Jones, 1996; 1997). Underlying fearfulness is the propensity to be more or less easily frightened and fear is one of the primary emotions with high adaptive value for feral animals. Domestic hens retain a high fearfulness. Sometimes this stimulates beneficial avoidance action, but it can also lead to deleterious consequences in intensive housing systems, including panic and hysteria leading to injury. In a general sense novelty per se is a particularly potent fear elicitor, thus, two of the commonest and potentially most frightening events encountered by domestic fowl are sudden changes in their social or physical environment and their exposure to people.

Stockpersons can minimise undue fear and distress by careful actions and by sympathetic handling of the birds. Experimental studies have shown that underlying fearfulness can be reduced to some extent by environmental enrichment and by regular handling or habituation to people (Jones, 1996). Human contact could become even more traumatic as increasing automation in the industry reduces the opportunities for the birds to become accustomed to people. Genetic selection can also reduce underlying fearfulness and this is a promising approach.

### **2.2.2. Aggression**

Aggression is a social response to conflict between animals (Huntingford and Turner, 1987). It is most commonly observed during conflict over resources but in many species, including chickens, overt aggression is reduced by the formation of a stable social hierarchy. Aggression may be high during the initial stages of hierarchy formation, or if the hierarchy is unstable. In chickens, aggressive pecks are distinctive, forceful, usually downward pecks aimed at the head or dorsal region of another bird (Kjaer, 2000). Recipient birds tend to move away to avoid being pecked. Feathers are sometimes damaged, but this is usually restricted to the head region (Bilcik and Keeling 1999). The term 'aggression' is sometimes used within the chicken industry to describe feather pecking or cannibalism. However, social aggression is quite distinct from these behaviours both in form and origin (Savory, 1995).

### **2.2.3. Deprivation and frustration.**

These states can be distinguished as follows: A bird may experience a sense of deprivation in the absence of a specific resource. A bird may experience a state of

frustration if a resource is present but cannot be accessed. New indicators of these states have been observed and experimentally verified e.g. particular vocalisations are given by frustrated hens (Zimmerman et al., 2000). Stereotypic behaviour was highlighted as an indicator of poor welfare in the previous report and, since then, there has been a large increase in published work in this general area. However, in the context of laying hen housing, stereotypes are rarely observed, with the exception of stereotyped pre-laying pacing which is occasionally observed in hens housed in conventional cages.

### **2.3. Health indicators**

All aspects of health in laying hens affect welfare. The question is more at what stage the health problem is serious enough to be a significant animal welfare problem for the bird. For instance an obviously inflamed and swollen foot pad, i.e. bumble foot syndrome, where the bird can be seen not to be able to stand properly and hence holds the foot up from the floor, is presumably more negative for the welfare of that bird than if the keel bone is physically twisted for instance 1 cm sideways without any other associated consequences.

High mortality rates are often a result of poor health and hence poor welfare. Thus, when mortality rate becomes very high the flock was normally hit by e.g. a certain disease, a parasitic infestation, heat stress or, possibly, by outbreak of cannibalism. Since all of these examples represent very serious threats to bird welfare, and hens suffer to varying degrees during the period of morbidity leading to death, mortality is a very important indicator of poor welfare.

It may, of course, be often difficult to evaluate the overall impact of a physical health problem. The bird may experience not only pain but also frustration or fear if it is unable to move around or perform certain behaviours like nesting, perching, etc.

Poor plumage condition through pecking may negatively influence welfare directly by pain from pulling feathers but also by difficulties in retaining body temperature often resulting in excessive consumption of food. Less protection against skin abrasion, draught and low temperatures are other negative effects. Similarly all wounds may cause physical pain to birds and may also indirectly be sources of infection and disease. Minor feather damage probably does not impair welfare very much. Wounds on the comb caused by repeated pecking can also be mentally distressing because they may reflect aggressiveness by another dominant bird. Wounds caused by accidents, i.e. trapping in equipment e.g. in the wire floor or in the nest bottom, may cause considerable suffering in a trapped position if the individual is not detected. Skeletal breakage is probably very painful until healing has taken place. Difficulty in moving around, especially in NC systems, to visit food and water becomes difficult and painful.

Foot disorders of different kinds as a result of poor hygiene or improper design of floors or perches negatively affect the welfare of the bird but probably not until the disorders become sufficiently obvious and serious. Hence, a very minor degree of disorders like hyperkeratosis on the digits or very early stages of bumble foot are less likely to be perceived as distressful or painful. Similarly, when the claws of birds do not wear and become long it is still not a big welfare problem until birds may get

trapped or claws break and/or bleed. At the same time very sharp and unworn claws may cause scratch wounds on other birds.

Finally, parasitic infestations like red mite cause both severe irritation and anaemia and sometimes increased mortality in the flock.

In conclusion, health characteristics are important indicators of welfare in laying hens. The severity of health disorders is of major importance. Also, before physical damage reaches a serious stage, mental effects causing poor welfare may have already started to develop. Physical damage and mortality and morbidity are important indicators of poor welfare.

#### **2.4. Physiological indicators**

Physiological variables are essential indicators of stress responses of animals but should be evaluated against a thorough analysis of the behaviour expressed and the emotional state. Indeed, the way in which birds respond will depend on where the threat to their welfare comes from and from their previous life experience.

Although it is generally assumed that stress is detrimental to welfare, there are also positive aspects, which are often overlooked. Some studies indicate that too much or too little stress is undesirable, and that a certain degree of stress is essential for maintenance of normal biological functions. Likewise, previous stressful experiences have been shown to have long-term benefits in helping an individual to cope with subsequent stressors (Zulkifli and Siegel, 1995).

When discussing stress, the nervous and endocrine systems are of primary focus (Siegel, 1971) and it is interesting to note that the role of neurobiology is increasing for the experimental assessment of welfare. External and internal stimuli are channelled via the nervous system to the hypothalamus. Once a stressor has been perceived, two distinct pathways involving physiological reactions are evoked, the hypothalamic-pituitary-adrenal (HPA) axis and the sympathetic adrenomedullary (SA) system, which lead to a very short-term response. Sapolsky (1992) indicated that damaging consequences of stress on health and welfare might occur when prolonged intense physiological responses are involved. One of the many means by which chronic stressors inflict damage to health is through constant mobilisation of energy. On the other hand, regardless of duration, continuous imposition of low intensity stressors may induce habituation without the development of a pathological state. Concerning the possible detrimental effects of stress, it is also essential that boundaries are drawn between acute and chronic stages of the stress response. Handling an untrained hen for a brief period will be perceived as an acute stress. Activation of the adreno-corticotrope axis of birds in response to an acute stress has been demonstrated (Siegel, 1971) and is reflected by an increased concentration of corticosteroids, mainly corticosterone in birds, in the plasma of the peripheral circulation (Beuving and Vonder, 1978; Harvey et al., 1980). Prolonged confinement in overcrowded conditions might be perceived as a chronic stressor which induces more long term changes in for instance sensitivity of the Hypothalamic Pituitary Adrenal (HPA) axis.

However, as with the other measures, difficulties may arise in interpreting results from a single point measurement. Indeed, changes in basal corticosterone levels can be associated with metabolic state and successive measurements will be necessary to access the real stressful effect. Moreover, increases are most often associated with situations that resemble those that humans find undesirable and it is therefore generally assumed that when its concentration increases, it is likely that the situation is bad for the bird welfare. However, that is not always the case, since increased concentrations of corticosteroids are also associated with experiences that are pleasurable such as sex and the anticipation of food (Toates, 1995). Changes in their concentration are thus rather a preparation for an action that may be either aversive or pleasurable, that is to say associated with poor welfare or welfare enhancement.

One of the most frequently measured physiological indicators of stress is the activity of the HPA axis. In poultry, this has typically involved measuring corticosteroid concentrations, adrenal gland weight and responses to ACTH (Adrenocorticotropic Hormone) challenge (Thorn et al., 1953) in order to measure the adreno-corticotrope axis sensitivity and maximal reactivity (Landsberg and Weiss, 1976; Koelkebeck et al., 1986; Mormede, 1988; Janssens et al., 1994; Guémené et al., 2001). The corticosterone measurement, with and without ACTH challenge, is submitted to a lot of possible variation due to the animal (individual variability), the environmental conditions during bleeding, the period of laying, the time between the challenge and the measurement, etc. Thus, the comparisons between results have to take in account these possible variability parameters.

Abundant literature substantiates the fact that chronic stress induces long-term changes in the regulation of the adreno-corticotrope axis (Janssens et al., 1994) in relation to steroid feedback. Indeed, chronic stress or repeated acute stresses such as repeated handling can bring about progressive decreases in corticosterone response or fear, in various species (Dantzer and Mormede, 1979; Jones and Faure, 1981; Grandin, 1988; Guémené et al., 2002). Thus, depending of the intensity of the chronic or repeated acute stressor the effect will vanish (low intensity such as repeated handling) or the HPA axis will become first hypersensitive then later exhausted (high intensity).

Assessment of an activation of the sympathetic adrenomedullary system can be done directly by catecholamine measurements in the plasma (Beuving and Blokhuis, 1997) or indirectly by heart rate frequency measurements. However, such measures are not easy to perform on a large scale basis, such as “commercial” conditions, especially in poultry, and for this reason will only be used in experimental approaches. It is possible to analyse the heart rate variability, an analysis that provides indications about the balance between the para- and orthosympathetic systems involved in the control of the heartbeat rate. As it is accelerated by the sympathetic system and slowed down by the parasympathetic system, the analysis of the variability of the intervals between two cardiac beats makes it possible to determine whether the control is under the prevalence of the ortho- or parasympathetic systems and to draw hypotheses on the animal emotional state. Indeed, stresses are associated with overall increases in sympathetic tonicity whereas feed consumption or rest are associated to a parasympathetic preponderance. It is further hypothesised that parasympathetic tonicity would be associated with more passive coping responses and vice versa (Korte 1999).

Some scientists suggest that there is a welfare problem when the stress response is of such a magnitude that it results in biological costs to the animal and the animal enters a prepathological state. Thus, Moberg (1996) argued that instead of measuring the stress response, we should be measuring the consequences of the stress, such as suppression of the immune system and for example failure to ovulate in laying hens. While measurements of HPA activity may be misinterpreted, entering a prepathological state clearly has an impact on the welfare of the animal. We would rather think that the impact of stress on immune and reproductive functions should be used as an additional indicator to the HPA activity one. Although there are discrepancies in susceptibility to different pathogens that might be attributed to effects of glucocorticosteroids on either the specific pathology involved or on immunological defence mechanisms (Siegel, 1980), stressors can impede production of antibodies and effective cell-mediated immunity. Owing to a change in the leukocyte population in relation to stress and especially with changes in plasma corticosterone levels, an increase in the heterophil-lymphocyte ratio (H/L) is also used as a stress indicator in birds (Gross and Siegel, 1983; Siegel, 1987; Mitchell et al., 1992; Maxwell, 1993).

At present, although some trials are on-going, available experimental data related to the comparative physiological indicators in laying hens kept in furnished cages, aviaries or any other NC system compared to conventional cages is very scarce. Physiological responses will also vary between breeds as well as within breeds, therefore the genetic effects should be taken into account. In addition, these criteria should be validated under different local conditions to prevent claims about welfare being based on poorly understood measures obtained in non-representative environments.

In conclusion, some corticosterone measurements can be very pertinent indicators of welfare. However, in order to use them, they would have to be put in the context of other measurements/observations.

## **2.5. Zootechnical indicators**

There are several examples of how zootechnical data e.g. number of eggs, egg weight, egg shell quality, feed conversion, misplaced eggs, etc. can give an impression of the welfare of laying hens. However, one should distinguish between a general impression of the whole flock from individual birds. Hence, low average flock production may be a result of a small proportion of birds not finding food or water soon enough e.g. due to unsuitable rearing methods being used for a multi-tier aviary system. In such a system birds have to be far more active when transferred to the laying house from the rearing in order to find the crucial nutrients like food and water than in a cage system where birds have these facilities within in close reach. An example of where daily egg production may be a poor indicator of welfare is if the proportion of misplaced eggs is considerable, leading to egg eating. These eggs are then not recorded, giving a false impression that egg production is lower than it really is. However there are examples where a low number of eggs collected can be a useful indicator of poor welfare in the system, e.g. birds do not use the nests, due to draughts in the nests or that they just cannot find them, or that the nests are occupied.

In general, high competition or aggression by dominant individuals at water or feed against low ranked birds will lead to insufficient water and nutrient intake in these birds which in turn impairs the average production of the flock and reduces the body weight. This will of course also happen if there is an insufficient provision of facilities like drinkers or feeders. Heat stress usually leads to a decrease in feed consumption, and panting. Both behaviours negatively affect egg shell strength and thus, lead to increase in proportion of cracked eggs - the former behaviour due to low intake of calcium and the latter through excessive expiration of CO<sub>2</sub>.

An example of an indirect indicator of jeopardised welfare is feed consumption in relation to plumage condition. Thus, a severely feather pecked bird may consume as much as 30-45% more feed than a well-feathered bird, due to increased heat loss. This is due to heat loss from naked or poorly feathered areas of the body (Tauson and Svensson, 1980; Pegurie and Coon, 1993). The increase in energy requirement may get so high that individual birds do not have the physiological capability to compensate enough for their heat losses, which may lead also to a lowered egg weight. This may happen in an almost naked flock, especially if environmental temperature is low, i.e. <18-20°C, since the energy requirement for a normally feathered layer increases by 1.5% per degree of Celsius. Hence, apart from any climatic and technical malfunctions, regardless of housing system, such effects are more likely to appear in poorly feathered flocks in free range, covered veranda or low stocked NC systems. In such cases the feed conversion ratio may rise from less than 2.0 kg of feed per kg of eggs to more than 2.5 kg/kg. In situations of heavy feather pecking, welfare may be impaired not only by the pain and stress of pulling out feathers but also through poor insulation. This would imply greater susceptibility to draught and moisture which in turn could be recorded as excessive feed consumption and a poor feed conversion ratio implying entrance into a physiological phase where energy balance could not be maintained.

Infestations of parasites like red mite may cause severe irritation in the plumage and skin and also start feather manipulation leading to plumage deterioration. Severe infestations of this parasite may also disturb birds from rest and sleep during the night causing distress and reduced production. Internal parasites like worms may reduce feed conversion efficiency. Several other diseases affect production results too. Typical examples are Avian Encephalitis where production drops drastically and does not recover until 7-8 weeks later, infectious bronchitis and coccidiosis.

External egg quality characters may also be the first indications of some disease and/or or stress. Thus, disorders in the crystalline eggshell structure have been shown to be caused by increased stress (Solomon, 2002). Furthermore, infectious bronchitis, egg drop syndrome (EDS) and Newcastle disease all affect egg structure mainly in the form of thin miss-shaped or over-calcified shells, lower dry matter in the albumen etc. Furthermore small red spots on the eggs shells indicate a welfare problem for the hens caused by a red mite infestation. These are all observations of zotechnical character that could be detected in the daily production.

In conclusion zotechnical parameters are not reliable indicators of welfare, but may be used as the first indication of a possible welfare problem. These parameters may be especially useful if sudden changes occur. Such indicators include:

- High or low feed and/or water intake
- Misplaced eggs
- Low egg production (number and weight of eggs)
- Poor egg shell quality
- Low body weight

### **3. HOUSING SYSTEMS: DEFINITION OF SYSTEMS, GROUPING OF EXISTING ONES, DESCRIPTION OF THE SYSTEMS**

Laying hens are housed in a variety of different systems. In Council Directive 1999/74/EC (later in this chapter often referred to as "EU-Directive") these systems have been categorised into 3 groups: NC systems, unenriched cage systems and enriched cage systems. The category "NC 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. As this may influence the welfare of laying hens, for this report this category has been split in some sub-categories. The categories of housing system, as described in this report, have been arranged in order from cages through to free range.

The results of housing systems are influenced by the system components used. Positioning and layout of equipment are important to safeguard bird welfare, hygiene and performance. The term "alternative systems" is used in the industry to refer to systems which are not conventional cages or to any non-cage system. 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 this report or in any future legislation. As explained below, a cage is considered here to be a system which is operated without the human keepers entering it. All other systems will therefore be referred to as "non-cage systems" (NC). As also explained below, a more accurate term for "enriched cage" is "furnished cage". The three types of system considered are therefore conventional cage (CC), furnished cage (FC) and non-cage (NC). To clarify what is meant by certain component names, a short description is given. As the successful operation of housing systems is also largely dependent on management, some details about this are included

#### **3.1. Cage systems**

New developments in housing systems sometimes make it difficult to distinguish between cage and non-cage systems. If the system is operated from outside and keepers do not enter the system it is regarded here as a cage.

Conventional laying cages (CC) 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 (FC) provide all the equipment found in conventional cages and in addition provide equipment intended to enable hens to provide for some of their strong behavioural priorities. 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 here 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 opinion whether or not it enriches it.

FCs come into a wide variety of group sizes. Up to 10 – 12 birds they are generally referred to as small groups (See Annex: figures 3.1, 3.2 and 3.3). At the moment larger cages may house up to 60 birds (See Annex: figures 3.4, 3.5 and 3.7). 15 to 30 birds could be regarded as medium sized groups and above this number they would be large groups. Neither the maximum or optimum number of birds is yet defined.

There are a wide variety of FC designs. Positioning and layout of equipment is important to allow proper use and thus contribute to bird welfare, hygiene and performance. Nest boxes can be placed at the rear, the side or close to the front of the cage. This can affect bird inspection and the hygiene of eggs and birds. Litter may be provided either in boxes or on mats on the cage floor (See Annex: figure 3.6). Litter boxes may be located over the nest or at a lower level at the side or rear of the cage. Perches can be arranged in a variety of positions and heights; some are more satisfactory than others. Cage dimensions are strongly related to group size and may influence bird inspection and depopulation.

### **3.2. Non cage systems**

These systems, which include those that fall into the category of the EU-Directive “Alternative systems”, are operated from inside and the keepers enter them. All current non cage (NC) systems provide the birds with nest boxes and litter as well as perforated platforms. Elevated perches may or may not be included.

#### **3.2.1. Indoor**

Indoor systems may, or may not, be combined with outdoor facilities.

Single level systems contain all NC systems where the ground floor area is fully or partially covered with litter and/or perforated floors in any combination. Birds have no access under the perforated floors. There is only one level for the birds at any one point, even if this level is stepped. (See Annex: figure 3.8).

Aviaries (Multi-level systems) consist of the ground floor plus one or more levels of perforated platforms, from which manure cannot fall on birds below. At some point across the system there are at least two levels available for birds.

There are many differences in layout. Three major categories can be distinguished.

- Aviaries with non-integrated nest boxes: aviaries with several levels of perforated floors with manure belts under them and separately arranged nest boxes (see Annex: figure 3.9) Feeders and drinkers are distributed in such a way that they provide equal access for all hens.
- Aviaries with integrated nest boxes: aviaries as above but where nest boxes are integrated within the blocks of perforated floors (see Annex: figure 3.10).

- Portal aviaries: aviaries with elevated perforated floors, the top tier of which is a single level which links the lower stepped platforms. The keeper can walk under and upon the top tier. Nest boxes are integrated in the system (see Annex: figure 3.11). Typically the litter goes fully under all the platforms, providing 100% littered ground floor

### 3.2.2. Outdoor

In combination with the above mentioned NC systems some additional area is provided.

This can be either one or both of the following possibilities:

- Covered verandas: a covered area outside, but connected to the hen house, is provided and can be available during daylight hours. This area has a concrete, or other suitable floor, usually covered with litter. The climate is similar to that outside except for rain (because of protecting devices). In some countries this area is referred to as a Wintergarten.
- Free-range: an outside uncovered area is provided, mainly covered with vegetation. Hens have access from fixed or mobile houses to this area via popholes in the wall of the henhouse and in the covered veranda, if present. Several pens may be used in rotation, or mobile houses may be moved, to control parasites and maintain good pasture quality. Areas near to the house may be covered with free draining material to maintain good hygiene both outside and within the house.

### 3.3. Others

Several systems do not fit into the previous categories, because they are obsolete or rarely used nowadays, e.g.:

- Litter-less or fully littered floor systems: obsolete as they do not meet the requirements of the EU-Directive (e.g. "perches must not be mounted above the litter").
- Tents: rarely used, but maybe suitable for certain situations.
- Percheries: obsolete as they do not appear to meet the requirements of the EU-Directive (e.g. "the levels must be so arranged as to prevent droppings from falling on the levels below").

### 3.4. Systems components

#### 3.4.1. Feeders

Feed is supplied by means of linear or circular troughs. These are generally well distributed to give easy access. Linear feeders can be either chain feeders, hopper feeders or those with flex auger or other conveyors to transport the feed. The trough can be either inside or outside the area accessible for the bird. If the feeder is outside this area, the hens can use only one side whereas feeders running through the accessible area can be used on both sides. Although the EU-Directive does not

mention the latter system for enriched cages circular feeders are applied in FCs as well.

#### **3.4.2. Drinkers**

Water is supplied in open water systems or by means of nipple drinkers. Open water systems include bell drinkers and cups of various sizes. Closed water systems include low and high-pressure nipple drinkers. Access to at least 2 nipple drinkers is provided.

#### **3.4.3. Cage gates**

Cage gates are usually constructed of sliding horizontal bars which reduce trapping and feather wear, facilitate easy inspection and improve feed trough access. Fully opening cage gates which allow almost the whole of the cage front above the feed trough to open (except for constructional margins) are now available on most makes of cage (Elson, 1990). Together with gentle handling, this reduces bone breakage when cages are depopulated.

FCs often may be equipped with similar cage gates as conventional cages. If feeders are located within the cage, there is no need for horizontal cage gate bars, so other designs sometimes are chosen (e.g. vertical bars or wire mesh).

#### **3.4.4. Claw shorteners**

Abrasives are provided in cages to shorten and blunt claws. A wide variety of such devices are now in use. These include perforated egg baffles, ceramic or other stones, abrasive paste, adhesive abrasive strips, abrasive faced metal plates. Some are more effective and durable than others (Elson, 2003). Also the effects of the abrasive may vary between different genotypes. The abrasive devices are generally fitted on the baffle plates behind feed troughs. The EU-Directive does not require claw shorteners in NC systems.

#### **3.4.5. Floors**

Most cage floors are constructed of rectangular welded wire mesh of various sizes and galvanised or otherwise treated to give them durability and a smooth finish. This is important to avoid foot and egg damage. Most often the wire mesh is about 50 mm by 25 mm, but 75 mm by 25 mm welded wire or plastic mesh of thicker gauge is sometimes used without apparent foot problems. In NC systems perforated floors constructed of plastic mesh or slats or of timber slats are in widespread use. Such floors often incorporate perches under, over or within them – see section on perches. Some FCs also have plastic slats as their floor surface.

The floors usually have a slight slope (max. 8°) so that eggs roll to the front or onto the egg belt. A well-chosen combination of materials, construction and slope is important to prevent foot problems

#### **3.4.6. Perches**

Perches are available in a variety of materials and shapes. Materials used include wood, plastic and metal. They should not have sharp edges. They can be arranged

at various heights and positions. In FCs they are usually positioned slightly above the cage floor. If the feed trough is inside the cage, often a perch is positioned on top of it. In NC systems perches may be located over, within or at the side of the perforated platforms, over feed troughs or on A-frames.

#### **3.4.7. Nest boxes including expulsion systems**

Nest boxes include single and colony models. They provide a separate, secluded space for egg laying, to which hens have easy access. The bottom can be lined with various materials, including artificial grass mats, rubber mats, plastic mesh or litter.

To prevent hens from staying in the nest boxes overnight and thus soiling the nest floor, expulsion systems may be used. There are basically two systems. One gently pushes and keeps hens out during the night. The other type is a door that in closed position prevents hens from entering the nest box, but allows hens to exit. Both systems are usually mechanised.

#### **3.4.8. Litter area**

In NC housing systems, the litter area is usually the floor surface of the hen house, or part of it, covered with litter. Often the floor is made of concrete, but other materials can be used as well. The litter area can also be located in boxes or on shelves. These can be large, as in some floor systems with wire floors and elevated litter boxes.

In FCs the litter area may be much smaller and needs frequent replenishment. In this system litter is provided on mats or in litter boxes. The former are often artificial grass mats fitted over the cage floor area. Any eggs laid on litter mats may roll onto the cage floor and thus onto the egg belt.

Opening and closing litter areas for certain periods may be used as a management practice to minimise floor eggs and to facilitate finding food and water. Types of litter used include sawdust, wood shavings, chopped straw, peat and sand. In some commercial FCs dry feed mash is used as litter.

Automatic litter supply systems can be used with suitable materials.

#### **3.4.9. Popholes**

Popholes allow hens access to the free-range area or to a covered veranda. They are distributed along the entire side of the hen house to allow all hens easy access to free range or covered veranda. The number of popholes is usually related to the number of hens in the house. In some cases instead of using popholes farmers simply open the doors of the henhouse to enable hens to go outside.

#### **3.4.10. Lighting**

In practice photoperiod length is usually between 12 and 17 hours in layers, often increasing as the hens increase in age (for gonadal stimulation). Good production

results can also be achieved with intermittent photoperiods (alternating short periods of light and darkness).

Light intensity necessary to keep a normal laying rate is 5 to 7 lux (Sauveur, 1988; Lewis and Morris, 1999). Morris (2004) showed a photoperiodic threshold at around 2 lux, but suggested that slightly higher values are sensible to recommend for laying houses because it is convenient for workers and allows for some variation in intensity in different parts of the house). Light intensities well over 10 lux are usually avoided to prevent serious feather pecking.

An even light distribution is desirable to minimise problems such as floor eggs, pecking or smothering. Where there is natural light, apertures are often shaded or baffled to avoid direct sunlight and thus arranged in such a way that light is distributed evenly within the accommodation.

For the first few days after housing light may be fairly bright. Later the light intensity should be such as to prevent health and behavioural problems

#### **3.4.11. Inspection systems (catwalks, trolleys)**

When multi-tier systems (both cages and non cages) are present inspection and removal of birds in some tiers may be difficult. Catwalks between tiers enable keepers to readily service birds. Trolleys or stepladders may also be used. These may be trolleys attached to one or more sides of the cage system, or free standing ones that pass through the aisles. They may be equipped with containers for various materials.

#### **3.4.12. Manure removal and storage**

Frequent removal of manure from the henhouse and manure drying reduces the ammonia concentration in the air.

Manure removal is generally mechanised using scrapers or belts. They may have air-drying systems ventilating and drying the manure. Air temperature can be increased with heating systems and/or heat exchangers using the heat of outgoing ventilation air to heat incoming fresh air.

A removal system is used to convey the manure from the end of the building to the container or storage area. Alternatively the storage may be underneath the building in a separate room.

Another approach is to store the manure in a pit underneath a perforated floor or below the house where it is stored and subsequently processed or spread on the land.

#### **3.4.13. System Management**

The effect of systems and system components on the welfare of hens is not only dependent on the design, but also on the management of the system. Even the best design can lead to failures if the management is not adequate. It is hard to give strict definitions of proper management. Some general aspects are given.

#### Rearing of pullets:

- success in the laying period will greatly depend on the housing and management in the rearing period. To facilitate a smooth start to the laying period it is advised to rear the pullets in a system that is similar to the system they will be housed in during the laying period and to transfer them into it well before onset of lay.
- feed and light management of the pullets will influence the production results later in life. Stimulation too early may lead to more egg laying problems. As the challenges hens meet in the laying period are different for cage systems and NC systems, the rearing management should be focussed on the demands of the laying period.

#### Feed and Water:

- Access to feed and water is influenced by: the distribution of feeders and drinkers in the system, the frequency of supply, the amount of water and feed available per batch.
- Good distribution of feeders and drinkers is important to allow easy access for all birds.

#### Light:

- The type of light source in combination with the positioning of the lights defines the distribution of light in the house. The location of the lights should be chosen to minimize the amount of shaded areas and thus the risk of floor eggs.
- The management of day length (the pattern of light and darkness) will influence the onset of lay and affect the distribution of the hens within the system. A proper dawn and dusk period will enable hens to perch and will minimise floor eggs.
- Different light intensities may be applied in different parts of the systems, e.g. the litter area may be slightly lighter than other areas in the system. Nest boxes usually have lower light levels to create a shaded place for the birds to lay eggs.

#### Perches:

- The use of perches will depend on several factors, including genotype, rearing experience, the available perch length and the provision of an acceptable perch position.
- Perch position can also influence soiling of the hens and litter, calmness of the flock and (vent) pecking.

#### Popholes:

The height of the popholes usually allows easy passage of the hens. Having more popholes or popholes with sufficient width can prevent one of a few hens blocking the passage of other hens. Large popholes not only give hens access to the outside area, but may also enable other animals to enter the house. Vertical bars spaced about 15 cm apart are sometimes used to prevent larger animals entering. The large openings may influence the climate in the house, especially in case of cold, wet and windy weather. If they open onto wet muddy areas, the litter within the house can

quickly deteriorate. Popholes may be protected e.g. with a small roof above, slats or free draining material around them and baffles to minimise wind entry.

(See annex: Figures from 3.1 to 3.11)

## **4. ANIMAL HEALTH AFFECTED BY SYSTEMS**

### **4.1. Introduction**

The evaluation of animal welfare requires information on all aspects related to the health status of the animals under consideration. Although animal welfare, in respect of infectious and production diseases, is a question of the state of individual animals, it is often, particularly in relation to egg laying hens, necessary to look into and draw conclusions from the flock situation. The evaluation of the impact of housing systems on animal health can be split into infectious diseases, parasitic infestations, production diseases and physical damage to individual birds.

Infectious diseases include a wide range of viral and bacterial diseases and are of great concern in modern methods of keeping hens. Successful vaccination programmes and management routines have reduced the risk of outbreaks of some of these diseases, while others still pose serious risks in modern egg production. However infectious diseases may also be linked to housing conditions, such as the effect of group size, air quality, presence and quality of litter and access to outdoor areas.

Parasitic infestations include a wide range of external and internal parasites. Internal parasites are usually related to housing conditions. Production diseases are metabolic and reproductive disorders. Physical damage includes injuries, abrasion and bone breakage.

The causes of many health problems are mainly multifactorial. For instance respiratory problems can have an infectious cause, but can also be induced by chemical contaminants in the air inside a poultry house. Causes of health problems often lead to more than one disease. For instance cloacal cannibalism causes physical damage, but is often also reported to be common in birds showing production diseases and infections like salpingitis (Engström and Schaller, 1993; Abrahamsson et al., 1998; Tauson et al., 1999)

### **4.2. Infectious diseases**

Most infectious diseases can show up in any housing system. However, some systems for layers increase the risk for specific diseases to develop and spread. The main potential risks lie in the area of biosecurity i.e. the hygienic situation and the large number of birds kept in close contact. Hence, good management practices are extremely important in such systems. This does not exclude the fact that the risk of disease may be very sensitive to housing systems or their components per se (e.g. Jansson, 2001). Examples are the presence of litter in floor systems or access to free range areas in comparison to cage keeping in small groups. Until recently there were few systematically documented reports in the literature about this. Therefore some conclusions were and still are drawn from routine investigations at autopsy at clinical veterinary departments and institutes where birds have been sent in from commercial production. There are several recent reports in which non cage housing systems have been widely introduced lately and where the incidence of bacterial/protozoa

infections like *erysipelas*, *E.coli*, *pasteurellosis* and histomoniasis and *Ascaridia* show a marked increased prevalence in floor-kept birds per se compared with cages (Häne et al., 2000; Hafez, 2001; Hafez et al. 2001; Permin, et al., 2002; Esquenet et al., 2003; SVA, 2004).

Some studies, strongly suggest that wild birds, especially ducks, are a source of infection for domestic poultry (Halvorson et al, 1982). Keeping birds outdoors allows more contact with wild animals and birds. Closing birds in their houses during the migrating season in these regions may decrease this risk (SANCO, 2003).

The National Veterinary Institute of Sweden (SVA, personal communication) reported on autopsied birds showing leucosis from both cage and floor kept flocks during a two-year period. Total mortality rates increased in both systems but considerably more in the floor flocks. The occurrence of infectious disease in FCs has so far been scarce and similar to in that conventional cages (Tauson and Holm 2002 and 2003; Van Emous et. al., 2003).

#### 4.3. Parasitic Diseases

Egg laying hens in any production system may be infested with a wide range of external and internal parasites. The most important parasites of egg laying hens in Europe are a few external species, particularly the poultry red mite (*Dermanyssus gallinae*). Other parasites include intestinal nematodes (roundworms), particularly *Ascaridia galli* and intestinal Protozoa, particularly coccidia belonging to the genus **Eimeria**.

The introduction of new regulations with regard to the compulsory declaration of Maximum Residual Level (MRL) values within the EU has reduced the legal use of most formerly used and effective drugs against parasites e.g. Permethrin. In many countries, depending on national legislation, no effective compound is approved for treating ectoparasites during production, although treatment of empty houses may be allowed. Thus red mite problems often recur in consecutive flocks in afflicted poultry premises. So far most new drugs have not been shown to be effective in the long run and so red mite remains a major and widespread welfare problem. There are also reports of the possibility of external parasites like red mite to serve as a potential vector for the bacteria *Erysipelothrix rhusiopathie* to cause erysipelas in layer flocks (Chirico et al., 2003).

A parasitic infestation where the number of parasites is below a certain level and there is a balance between host and parasite will not normally create a health problem for the host. If, however, this balance changes and the parasites increase in number, the infestation often produces clinical symptoms. Many factors affect this, particularly the host's general health status and immunological capacity and the parasite pathogenicity. The general hygienic level in the poultry house, including possibilities for cleaning and disinfection, are the factors producers can manage to keep the right balance between host and parasite.

The survival or reproduction of an ectoparasite like red mite in a given egg production system is also influenced by environmental factors, including temperature, humidity and the construction of fittings. Poultry red mite, for example, has better opportunities

to reproduce and to infest hens in poultry houses rich in fittings such as roosts, nests, slatted floors than in conventional laying cages where the mites may find it more difficult to survive outside the host (Loomis, 1984; Maurer et al., 1988). Höglund et al. (1995) reported from inquiries to commercial flocks on the prevalence of red mite to be 4% in conventional cages, 21% in non cage floor systems and 19% in hobby flocks on floor systems. However, when checked on the farm the true occurrence was found to be 6%, 33% and 67% respectively. Van Emous and Ficks-van Niekerk (2003) reported that all 25 commercial aviary free range flocks included in their survey showed the presence of red mite to varying degrees. Guy et al. (2004) in a survey on 29 UK farms, showed that the population of nymph and adult mites was significantly higher in free-range compared with either non cage or cage systems.

Fittings in FCs increase the number of areas where parasites, mainly red mites, may live and survive. Also the risk of coccidiosis can be increased by the location of extra facilities causing manure to build up, e.g. under perches. Tauson and Holm (2002 and 2003) reported examples of results from good and bad designs in this respect in comprehensive field investigations. In these studies red mite infestations were rare in FCs but they may be higher in the future due to increasing exposure to this ectoparasite.

Intestinal parasites, including worms and coccidia, may survive, reproduce and create disease problems when the hens are in close contact with their droppings e.g. in litter systems, particularly if droppings accumulate in wet conditions (Morgenstern, 1986; Braunius, 1989; Morgenstern and Lobsiger, 1993; Engström and Schaller, 1993; Bosch and van Niekerk, 1995. Also, according to Bray and Lancaster (1992) the highest concentration of eggs from intestinal worms was found in the surroundings close to the houses in free range poultry systems. A recent large investigation on the occurrence of worm infestations in floor kept birds compared with conventional cages showed that the latter system had very low (5%) amounts of worms while the former had more than 70% (Permin et al., 2002). In many cases this trend appears both when birds have access or not to a free-range area although, outdoor keeping poses a higher risk (Jansson, 2001; Permin et al., 2002) due to difficulty to ensure biosecurity. For instance, Permin et al. (2002) reported the occurrence of *Ascaridia galli* in organic layers, single level NC systems and cages to be 72%, 20% and 4% respectively and of *Capillaria obsignata* to be 52%, 51% and 0% respectively. In most cases where these diseases have occurred the mortality rates have risen to high or very high levels that seriously compromise animal welfare.

#### **4.4. Production Diseases**

##### **4.4.1. Diseases of the reproductive organs**

Reproductive disorders are commonly diagnosed during autopsies of egg laying hens. These disorders include salpingitis, impaction of the oviduct and prolapse of the oviduct and cloaca, and are often followed by peritonitis and other abdominal changes. The disease complex is often related to the growth of coliform bacteria in the oviduct (Gross, 1984), and a high level of production with high oestrogenic activity seems to be associated with this bacterial growth. Since the Scientific Veterinary Committee Report 1996 report little new data from extensive surveys has become available. However, Abrahamsson et al. (1998) reported salpingitis in a

5000-bird aviary system over five production cycles to vary between 1 and 8% or 10-35% of the total mortality - the highest figure when occurrence of cloacal cannibalism was most common. In smaller scale studies Abrahamsson and Tauson (1995) reported Lohmann Brown non beak trimmed birds to show 14% mortality in aviaries and 9 % having wounds but De Kalb white layers showing 2.2% and 0.2% respectively. Hence, the genotype and pecking activity may interact with occurrence of salpingitis. Abrahamsson and Tauson (1997) reported mortality due to salpingitis to be less than 1% in both CCs and FCs.

Reproductive disorders do not seem to be related to any particular housing system although salpingitis and peritonitis may be caused by pecking around the cloacal region which was shown to be more common in layers in NC systems (Engström and Schaller, 1993; Ekstrand et al., 1996; Abrahamsson et al., 1998) and in aviaries, when birds were not beak trimmed (Michel and Pol, 2001), than in conventional cages. The high egg production may itself be a stressor which, in combination with a reduction in the immunological capacity due to a high level of oestrogenic hormones, may decrease the bird's general resistance to disease. Housing systems in which other stressors are present, e.g. crowding, social stress and lack of general stimulation, may further increase the risk of infection and clinical disease of the reproductive tract.

#### **4.4.2. Fatty liver Haemorrhagic syndrome (FLHS)**

FLHS is a typical production disease mainly encountered in conventional caged egg layers. There are no data available on the incidence of FLHS in FCs. A larger total area available, stepping up onto perches and movement into litter boxes would imply more exercise while resting on perches would be energy saving. According to Peckham (1984) the typical sign of the disease is a decrease in rate of lay. Birds visually appear healthy and in good physical condition but there may be a 25-30% increase in body weight. Such birds may die suddenly, without premonitory signs, from rupture of the liver. The capsule around the liver is torn, and large blood clots are present on the surface of the liver and in the body cavity. Large deposits of fat may line the abdomen and cover the intestines.

In an older review of the literature on FLHS (Squires and Leeson, 1988) four factors are mentioned as responsible for FLHS. Among these factors environmental conditions such as high temperature, stress, and lack of exercise due to crowding may be important in relation to the housing of egg-layers in different systems. Simonsen and Vestergaard (1978) concluded that important factors related to FLHS were restricted locomotion, high environmental temperature and a high level of stress. No new data on FLHS as related to keeping systems are available.

#### **4.4.3. Osteoporosis**

Bone fragility in egg laying hens is a well-known condition that is related to several causal factors including nutritional imbalance, the level of egg production and the birds' possibilities to move about and thereby keep their bones and muscles fit. As bone fragility may lead to bone fractures the condition is very important in relation to the welfare of laying hens.

Skeletal weakness in hens was first reported as cage layer fatigue after the introduction of CCs in the USA (Couch, 1955). The problem has been identified as a general loss of structural bone leading to weakening degeneration and fractures of bones. Wilson et al. (1992) confirmed that the bone loss is caused mainly by the progressive development of osteoporosis and Whitehead and Wilson (1992) described how an apparent lack of new bone formation in reproductively active hens leads to a progressive loss of structural bone during the laying period. Although lack of minerals in the feed of the high-yielding hen as well as egg production per se may weaken in particular the leg and wing bones, it is generally accepted that restriction of movement is the main cause of bone fragility in egg laying hens (Simonsen and Vestergaard, 1978; Hughes and Appleby, 1989; Nørgaard-Nielsen, 1990; Knowles and Broom, 1990; Fleming et al, 1994; Michel and Huonnic, 2003). Increased opportunities for movement can improve bone strength to a certain extent. Fleming et al. (1994) concluded that hens in CCs had the poorest bones compared with birds housed in a variety of NC systems, by measurements of cancellous bone volume, radiographic density, cortical thickness and three-point breaking strength. Bosch and van Niekerk (1995) found that aviary hens had stronger measured bone strength than caged layers. Increased tibia and humerus strength has been recorded in FCs, when birds have access to perches (Hughes and Appleby, 1989; Abrahamson and Tauson, 1993; Hughes et al., 1993). Exercise during the rearing period is also important. Michel and Huonnic (2003) showed that rearing pullets in multi-tiered aviaries compared with rearing on single level floor with perches increased bone strength significantly. Clear differences in bone strength between different breeds were observed by Leyendecker et al (2002b). Lohmann Tradition (LT) showed significantly higher strength of tibia and humerus compared to Lohmann Selected Leghorn (LSL). Highest fragility was found in bones of birds reared in CCs as compared to FCs and intensive free range. Recent results indicate that bone strength of birds reared in modern FCs is similar to birds reared in aviaries (Leyendecker et al. 2004, submitted).

Laying hens exposed long-term to certain types of perch tend to develop deformation of the keel bone (Moe et al, 2004), although this may not be a great welfare problem unless bursitis occurs. Keel bone deviation is very rarely observed in CCs or systems where perches are absent (Abrahamsson and Tauson, 1995), but tends to occur in systems where birds roost on objects such as the edges of feed troughs, water pipes, wires or litter boxes, thereby applying pressure to the keel. The incidence of keel bone deviations in commercial flocks of two models of small group FCs was shown to be between 0-4% and 0-17% and 0-7% and 0-12% at 35 and 55 weeks respectively (Tauson and Holm, 2002; 2003). In multi-tiered aviary systems similar values were reported by Algers et al. (1995) and Tauson and Holm (1998). Bursitis occurred only in a minority of cases.

Attempts to avoid the problem of keel bone deformity have focussed on altering perch design and on rearing practices. Tauson and Abrahamsson (1994; 1996) demonstrated that perches with a soft rubber cover did not significantly reduce keel bone lesions as compared to perches made of plain European beech hardwood. The design of perches is normally a compromise between creating a relatively flat surface to reduce pressure on the keel bone and minimise lesions, and making the perch sufficiently round for the birds to grip. Gripping reduces dirt on the perch surface and, consequently, the incidence of bumble foot, i.e. swollen footpads (Tauson and

Abrahamsson, 1996). Moe et al. (2004) showed that rearing pullets on floors with perches compared to rearing in cages reduced keel bone deviation in hens subsequently housed in FCs during the production period.

#### **4.5. Physical damage**

##### **4.5.1. Plumage**

Regardless of currently used housing systems, feather cover of laying hens usually deteriorates by age. In serious cases the loss of feathers may be both a welfare and an economic problem. The causes of plumage deterioration are mainly two: feather pecking and/or abrasion against equipment. Damaged feather cover may interfere with the bird's body heat regulation and in crowded systems may give rise to skin damage caused by wear and tear from the environment and flock mates. Beak trimmed hens may perform as much feather pecking as non-beak trimmed hens, but the damage caused to plumage will be less. Therefore beak trimming can have a major effect on plumage condition in different systems.

In CCs the use of solid sides can improve feather condition significantly explained by both less abrasion and pecking within or between the cages (Tauson, 1984) using non trimmed birds and Barnett et al. (1997) using trimmed ones. The latter authors also reported lower stress levels as indicated by H/L ratio's or corticosterone levels after challenging birds with ACTH in the solid sided cages than both in the CCs and in floor pens also included in the study.

The most common way of determining differences in the plumage condition is by scoring the integument of the birds at different ages. Since there are different scoring systems it is not always easy to compare results from one study to another. However often there are quite clear effects between housing conditions within each study. Furthermore scoring different parts of the body may help identify the cause of feather damage (e.g. Bilcik and Keeling, 1999).

Abrahamsson and Tauson (1995), in two consecutive trials carried out with non-beak trimmed LSL (Lohmann selected leghorn) hens in two designs of aviary and in CCs in the same building, reported the plumage scores for the total body at 55 weeks of age to be on average 17-44% better in birds from the CCs. Abrahamsson et al. (1996) using the same basic systems found scores of birds in the two aviaries to be 33% inferior than in the CCs but also a 22% general increase in plumage condition when a high barley based diet was used compared with a high wheat based diet. Similar positive effects but with oats compared to wheat were reported by Wahlström et al. (1998a). In a large experiment Michel and Huonnic (2003) reported mild to severe plumage loss of 30.9% of animals in CCs vs. 25.9% and 27.3% in two aviaries. Van Emous et al. (2003) showed that different light sources might affect plumage condition, judged by the incidence of feather pecking shown in a 50 bird FC model.

A very clear effect of housing per genotype interactions in non-beak trimmed birds was reported by Tauson et al. (1999) where plumage condition in LSL hens were on similar levels in two aviaries as in CCs but where it was 71% better in the latter system in Lohmann Brown birds. There are no reports available on the comparison in

the same environment of FCs and birds in NC systems. However, Tauson and Holm (2001) with white non trimmed layers from the same hatch but in two parallel buildings with 8-hen FCs and a traditional single level NC system on a commercial farm reported from two consecutive flocks that naked areas on the backs of birds were found on average on 83% in the NC system birds and 16% in the FC birds. Abrahamsson and Tauson (1997) reported plumage scores to be 17.0-17.4 in 5-8 hen FCs and 15.1 in 4-hen CCs at 600 cm<sup>2</sup> /bird in white non trimmed layers. In long term experimental studies with a range of different small group FCs (4-8 birds), Appleby et al. (2002) found feather damage generally to be less in FCs than in CCs using non beak trimmed ISA Brown layers. Using a low stocking density in 3-bird CCs (736 cm<sup>2</sup> /bird) Hetland et al. (2004) found inferior feather cover in 8-hen FCs but Moe et al. (2004) showed that when the pullets were reared in floor systems, i.e. with access to litter there were no such differences. Again when using litter reared pullets, Guémené et al. (2004) found a strong negative effect on plumage condition in non-beak trimmed birds compared with beak trimmed birds kept in both CCs (5-6 birds/cage) and FCs at medium group sizes (15 birds/cage). There was no consistent effect reported of CCs vs. FCs but rather between models within each of the categories. It was concluded that the enrichment in the FCs might have reduced the expected negative effect from a 3 times larger group size. Some studies in research facilities when larger group sizes have been used report considerable feather loss especially in non-beak trimmed birds, e.g. Guémené et al. (2004) although values varied among designs of cages. Hadorn et al. (2000) showed that beak trimmed birds housed in aviary systems kept their plumage condition at an "acceptable" level while the control group of non beak trimmed birds worsened drastically. A mortality rate of 2.2% and 12.3% respectively mainly due to cannibalism followed the feather pecking. Nicol et al. (1999) found a successive decrease in plumage condition in birds housed in percherries from 6-30 birds/m<sup>2</sup>. Hence, it has been shown that increased stocking density in some NC systems as well may impair plumage condition.

From evaluation programs on testing of new systems in commercial non-beak trimmed flocks in Sweden there are lots of data on both aviary systems and FC models reported during the mid 1990's until 2003. Hence, Algers et al. (1995) reported prevalence of birds with naked back areas in 17 flocks of Oli-free aviary system to be 83% on average and Ekstrand et al. (1997) reported the same trait to be 58% on average in 26 flocks of Vencomatic aviary. Using the same method of investigation some years later Tauson and Holm (2002) reported this figure to be 22% in 17 flocks of the Victorsson 8-hen FC and Tauson and Holm (2003) found in 13 flocks with the Aviplus 10-hen FC 21% of birds with naked back areas.

Bestman and Wagenaar (2003) reported 33 flocks out of 63 (52%) in 26 farms studied in the Netherlands to have "severe" plumage damage in organic egg production, i.e. with free-range non-beak trimmed birds. "Little damage" was reported from 18 flocks (29%).

### Feather pecking

Since the publication of the 1996 Scientific Veterinary Committee report, the problem of feather pecking has been extensively studied, taking nutritional, ethological, physiological, ontogenetic and genetic approaches (e.g. Albentosa et al., 2003;

Hocking et al., 2001; Kjaer and Sorensen, 1997; Kjaer and Vestergaard, 1999; Korte et al., 1997, Korte, 1999;; Rodenburg and Koene, 2003, 2004; Rodenburg et al., 2003; Savory and Mann, 1997; Van Hierden et al., 2002). Epidemiological studies have also started to investigate the role of managemental risk factors in commercial settings (Gunnarsson et al., 1999; Green et al., 2000).

Several authors have stated that feather pecking is a form of redirected food- and ground pecking (e.g. Blokhuis, 1986; Huber-Eicher and Wechsler, 1997; Klein et al., 2000) or redirected pecking during dustbathing (Vestergaard and Lisborg, 1993). argued that gentle feather pecking at an early age reflects social exploration rather than redirected ground pecking.

The relationship between the development of feather pecking and physiological and neurobiological characteristics of laying hens was also studied (Korte et al., 1997; Van Hierden et al., 2002). It was shown that plasma corticosterone levels and both dopamine and serotonin turnover were lower in a line of high feather pecking chicks compared to low a feather pecking line. These differences fit well with the differences found in rodents with different coping strategies, i.e. proactive and reactive animals.

Rodenburg and Koene (2004) concluded that birds with a low open-field activity at a young age and a high open-field activity at an adult age show lower levels of pecking behaviour as adults and thus that feather peckers are indeed more fearful and have a lower social motivation than non-feather peckers.

Also a clear genetic component of feather pecking is demonstrated (see review Kjaer and Hocking, 2004) and heritability of observations of pecking behaviour range from 0.06 to 0.38. Chromosomal regions (QTL's) were identified that were associated with gentle and severe feather pecking (Buitenhuis et al., 2003).

Kjaer and Hocking (2004) conclude that “molecular approaches may offer the opportunity for selection to decrease feather pecking and cannibalism without compromising the welfare of birds in the selected flock. However, the evidence so far is not encouraging, and future opportunities to change the propensity for damaging feather pecking and cannibalism in commercial laying hens will probably rely on conventional selection in appropriate environments”.

#### **4.5.2. Wounds and Cannibalism**

Wounds in laying hens usually originate from pecking at the skin, e.g. on the back, cloacal region, wings or head. Cannibalism is the pecking and tearing of the skin and underlying tissues of another bird and can be divided into two main types, that directed at the feathered part of the body and that specifically directed at the cloaca, which is also called vent pecking. Toe pecking is a specific type of cannibalism and it is often directed at the bird's own body and will not be dealt with here. In the previous report, the section on cannibalism summarised the research, but the only statement in the conclusions referring to cannibalism was that the risk is high in non cage housing systems such as aviaries, percheries, deep litter or free range compared to CCs if the birds are not beak trimmed (SVC/EC, 1996; point 11 page 109).

As with the status of plumage there are different scoring methods used for evaluating the status of wounds on different parts of the body which means that it is important to compare effects of housing systems or genotypes mainly within studies from different laboratories or practical farms rather than between studies.

The extent to which wounds occur is often related to the housing system. Abrahamsson and Tauson (1995) reported ventral wounds in two aviary systems in Lohmann Selected Leghorn (LSL) non-beak trimmed birds to be 42-49% while in CCs it was 21% by 80 weeks of age. The corresponding figures for dorsal wounds in the same systems were 39-68 % and 21% respectively ( $p < 0.01$ ). Algers et al. (1995) reported comb wounds in a field investigation of a large number of commercial flocks of an Oli-free aviary and non trimmed birds to vary at 75 weeks of age from 2-45% of scored birds and Ekstrand et al. (1997) reported 1-30 % comb wounds also in a larger field investigation. In a comparison of a single level traditional litter system and FCs in two parallel houses in commercial production over two flocks, Tauson and Holm (2001) reported comb wounds to be 61% (33-94%) and 14% (13-18%) respectively. The corresponding figures for wounds on the rear part of the body were 23% (6-42%) and 5% (1-8%). The median value of cloacal cannibalism in an epidemiological study of 59 flocks of various hybrids on 21 farms with aviary systems in Sweden in the mid 1990's was 2.65% with a 0.4%-12.6% (90% central range) (Gunnarsson et al., 1999). In a more recent large questionnaire study of 198 flocks on the UK in free-range, barn or perchery systems, Pöttsch et al., (2001) reported a median mortality of 1.3% representing 19% of the total average mortality with a median of 3.5% of the flock affected. In 49% of the flocks there was an association between a higher flock mortality than 7% and vent pecking ( $P < 0.01$ ). Of the responding farmers 27% reported vent pecking as a regular occurrence in their flocks, 31% that they saw hens eat flesh of others and 71% that blood was seen around the vent. Measures taken to reduce pecking were reported by 32% of farmers and included e.g. dimming of lights, beak trimming and spraying birds with tar - all well known traditional measures. None of the birds in Sweden would have been beak trimmed, whereas in the British study 96.4% of the flocks were beak trimmed as chicks and 2.1% after the onset of lay. These studies probably give a picture of the magnitude of the problem with cloacal cannibalism in flocks of laying hens, but one is almost ten years old and the other based on farmers' own assessments of the problem.

Michel and Pol (2001) found that mortality due to injurious pecking (directed at all the body or especially at the cloaca) is more important among non-beak trimmed hens than beak trimmed ones, especially in aviaries (0.7% vs. 0.3% in cages and 2% vs. 0.2% in an aviary for non beak trimmed and beak trimmed hens respectively). In another study where two models of FCs and two of CCs were compared, the overall mortality was between 3 and 7% among beak trimmed birds and between 36 and 52% (essentially due to cannibalism) for non-beak trimmed birds (Guémené et al. 2004). Although, such high levels of mortalities are very scarce especially in cages, they were significantly lower in the two FC models than in the CCs

#### **4.5.3. Injuries due to accidents**

All housing systems for egg laying hens present a potential risk of different kinds of injuries to the birds. Accidental trapping in equipment may cause injuries by birds'

hocks in wire floors or by the head or toes in other parts of the equipment. Not many studies report on these types of damage, although they may cause serious welfare suffering through injury. These kinds of injuries were reduced dramatically in birds in CCs - Tauson (1985): commonly used CCs showed large differences in mortality rate due to trapping accidents including trapping of the head, neck, toes, claws, hocks and wings. According to Abrahamsson (1996) injury and mortality due to trapping is rare in well-designed modern cages in good condition. The same was shown by Tauson and Holm in small group FCs where accidental trapping mainly in new models was always less than 0.4% (Tauson and Holm 2002 and 2003). Ekstrand et al. (1997) reported injuries due to accidents in their field investigations of farms with Vencomatic aviary systems to be between 0.1 and 1.6% of hens housed.

Due to the large number of birds housed in NC systems, there is a risk for suffocation by crowding. In a Swedish study this caused 2,2% mortality (36% of total mortality) in a flock (Tauson and Holm, 2001), but anecdotal evidence suggest that mortality can be much higher at such occasions. In a Dutch survey on commercial free range farms in 8 out of 25 flocks mortality due to suffocation by crowding was reported, leading to about 2% mortality in 4 flocks and about 5% mortality in the other 4 flocks (Van Emous and Fiks-van Niekerk, 2003). The majority of the casualties were found in the free range area. Hence, fright, e.g. thunder, aeroplanes flying over, sounds inside the house or just sudden unexplained hysteria and crowding in corners, may cause considerable mortality in larger flocks. Higher attractiveness and thus, excessive use of the end nest boxes of an NC system may also pose risks for suffocation in individual birds when sitting/lying on top of each other. Sometimes these nests are removed during the first period of production. Bright spots on litter floors from natural light may also cause crowding and problems with suffocation.

In free range and other 'open' systems, birds may be exposed to low temperatures with the risk of frostbite of the comb and wattles (Elson, 1990). However, statistics about these injuries are not available. In free range systems losses may occur due to attacks by predatory bird or animals such as hawks and foxes. Löliger et al. (1982) reported that in 3 trials with free range Leghorn hybrids, losses due to predators were 3.8%, 10% and 21 % respectively. These attacks may often, but certainly not always, result in quite a quick kill of the birds. A recent paper from Moberley et al. (2004) give lower figures for fox predation of mean 1.99% (SE 0.41), median (0.5) and range 0-11.3) on 50 farms in Britain.

#### **4.5.4. Foot disorders and claw condition**

Foot disorders. Foot damages of different kinds are common in egg laying hens. Damage is seen in all systems, but its character and severity usually differs from one system to another. The condition known as bumble foot is a local infection which causes a bulbous swelling of the footpad. Other types of damage include ulceration under the toes, and broken claws. Hyperkeratosis of the claw fold is mostly located on the distal toe pad. 'Balling' of the claws may be seen especially in hens in close contact with wet droppings and mud where dirt may aggregate around the claw base.

Bumble foot develops in the footpad and eventually often reaches an acute state with severe inflammation that is very painful. The acute state usually occurs around 30-40

w.o. The effect of genotype is also indicated by recent data. Thus, Abrahamsson et al. (1998) and Tauson and Abrahamsson (1997) reported differences between genotypes implying a higher incidence with LSL birds which is increased on plastic perches of mushroom shape. Tauson and Abrahamsson (1996) compared foot health in hens housed in get-away cages and CCs and it was found that bumblefoot lesions appeared only in Get-away cages while toe pad hyperkeratosis was found in the CCs only. Scores for bumblefoot were significantly different between different hybrids. In this study it was found that plastic was not a suitable material because it increased the incidence of bumblefoot, and that a soft rubber cover did not reduce bumblefoot compared with plain European beech hardwood perches of equal diameter. Using a flattened top hardwood 38 mm diameter circular perch was found to give the lowest incidence of bumblefoot and this design seems to be the best currently known type of perch in current knowledge (Tauson and Abrahamsson, 1997). Alternatively a ventilated design where the foot is not in contact with moisture and faeces for long periods i.e. when at rest may be good (Oester, 1994).

Several recent studies show that the hygienic conditions in a system and moisture especially have a great impact on the incidence of bumblefoot. Hence, Tauson and Abrahamsson (1997) showed that in Get-away cages, where perches were at two levels and thus the hygiene of the cage floor and birds' feet were poor, and in aviaries, bumblefoot was very common. This was especially evident with plastic mushroom shaped perches. Tauson and Holm (1998, 2001, 2002) on commercial farms showed that bumblefoot in small group FCs of the Victorsson model was below 5% but in aviaries and traditional litter floors on average 3-4 times as high. Similarly, Wang et al. (1998) showed that moisture on perches or litter increase the incidence of bumblefoot 3 times compared to when these areas were kept dry.

In many of the studies mentioned above the classical 50x25 mm soft wooden perch has caused major problems probably because manure and moisture build up on top of it which the birds then rest on for long periods.

Claw condition. White laying hens in cages, especially, may have an excessive growth and length of claws, often leading to breakage and sometimes trapping of the claw, with or without damage of underlying tissues (Tauson, 1986). The claws may often also become sharp and may damage both the skin of other birds and the wrists of operators handling the birds. By fitting an abrasive strip on the baffle plate behind the feed trough in cages the front claws are effectively shortened and become blunt. (Tauson, 1986; Elson, 1990). The use of abrasive strips for medium heavy brown genotypes is less necessary because their claws do not grow so long. Thus, Michel (2002) showed that claw length in ISA Brown layers was the same in aviaries compared with conventional cages but that body injuries were higher in the aviaries (4.7%) than in the cages (3.1%). Even claws from these hens may be sharp if no abrasive device is installed. Excessively abrasive materials may cause too much wear especially for claws of brown layers where claws are shorter (Roll et al., 2004).

Since the findings on the concept of claw abrasives were originally reported a whole variety of materials have been studied in order to find durable and effective abrasives suitable for use on commercial farms. Although the abrasive self-adhesive tapes used originally have seldom proved durable enough for long term use, a range of suitable abrasives of various types e.g. ceramic plate, tungsten carbide strip, coined

embossed metal, holes punched in the baffle plate and abrasive paste which hardens have been monitored and found to be durable and effective without causing welfare problems (Secher, 1998; Niekerk and Reuvekamp, 2000a; Fiks-van Niekerk et al., 2002; Elson, 2003; Fiks-van Niekerk et al, 2003

#### 4.5.5. Damage to bones

##### At Depopulation

At the end of the economic laying cycle there is a requirement to remove birds from their environment and to replace them with a more productive, younger flock. Regardless of the design of the housing system, the human intervention required at this stage has a huge impact on the birds being handled, and considerable stress and injury can be inflicted at this time.

The basic design of all cage systems means that depopulation involves removal of the birds through sometimes limited, rigid openings, with the associated risk that birds may acquire severe damage, including broken bones, through contact with the cage structure. The likelihood of such damage occurring is greatly increased where insufficient care is exercised. Caged hens are particularly susceptible to such injury due to the fragile, brittle nature of their bones as a dual consequence of increased egg production and the limited opportunities for exercise and activity imposed by the cage environment (Simonsen and Vestergaard, 1978; Nielsen, 1980; Wokac, 1987; Gregory and Wilkins, 1989, Michel and Pol, 2001, Michel et al, 2003 a and b).

Objective appraisal of the occurrence and extent of skeletal damage incurred during depopulation and delivery to the abattoir requires the careful collection, euthanasia and whole-bird dissection of large numbers of birds. It is important that the sampling procedure does not itself result in damage. Studies that have assessed leg and wing fractures of processed carcasses at hen slaughter plants have little value in the case of caged flocks, since the majority of breakage which occurs during depopulation is to the skeletal frame rather than the limbs (Gregory and Wilkins, 1989). Broken bones can occur after death, during further commercial processing. Broken bones sustained after death are not a welfare concern. Despite this, examining birds post-processing can be useful in exemplifying differences in bone strength between flocks from different housing systems. Thus, studies have shown a much higher incidence of wing breakage for caged birds than aviary birds (Michel and Pol, 2001; Michel, 2002 and 2004; Michel et al, 2003a and b). Michel and Huonnic (2003) found at the slaughterhouse < 1% of recently broken wing bones in aviary birds but almost 20 % in conventionally caged birds (samples of 1080 birds). However, because these fractures could have been caused during catching and transport, or during the slaughtering process, it is difficult to assess whether the breaks occurred before or after death.

Gregory and Wilkins (1989) found that up to 29% of birds housed in conventional cages had incurred one or more broken bones during depopulation, before the point of stunning and slaughter. Much of the damage was to the keel and ischium/ileum and was thought to be caused as the birds were pulled backwards through limited

cage openings (Gregory and Wilkins, 1989). The methods employed to remove the birds from the cage can have a major effect on the amount of damage sustained, so improved handling techniques which are less influenced by time pressures can considerably reduce the incidence of breaks (Gregory et al., 1993). Handling birds individually and holding them by two legs, rather than by one leg, during removal from the cage is particularly important (Gregory et al., 1992). Features of the cage design, particularly the entrance, can also influence the difficulty of removing birds. Modern cages have fully opening fronts to allow easier access, but FCs also incorporate other hard structures such as perches, which may increase the risk of damage at depopulation. Studies are needed to assess the risk associated with modern FC designs.

A general principle employed during catching of all poultry species is to try to reduce bird activity by keeping light levels to a minimum. A single study concluded that where the light intensity at catching was the same as that during lay, regardless of actual intensity, birds were more difficult to catch than when the light intensity was reduced. However, effects of bird activity did not influence the incidence of broken bones incurred (Gregory et al., 1993). Environmental enrichment during the laying period may help to reduce the fear response elicited by the depopulation procedure itself and hence reduce the likelihood of injury occurring (Reed et al., 1993).

Removal of hens from NC systems requires a different strategy. The freedom of movement such system allow leads to improved bone strength, reducing the susceptibility to breaks during depopulation (Bosch and van Niekerk 1995) but allows a greatly enhanced opportunity for escape behaviour increasing the risk of injury. The catching of the last 10-15% of the birds may also prolong the time for collection and hence, increase stress in these birds. In general, increased system complexity increases the difficulty of capture. Despite the risks of escape behaviour, the prevalence of broken bones sustained during depopulation is considerably lower than that observed during depopulation of caged hens. During the clearance of complex perchery systems, the prevalence of birds with breaks incurred during the operation has been reported as 7% (Gregory and Wilkins, 1996), 3 to 9% (Gregory et al., 1991) and 10% (Gregory et al., 1990). Where birds are housed in free-range systems the catching operation is largely determined by the design of the housing element, which is highly variable. A single study has reported the prevalence of free-range birds with broken bones sustained during depopulation to be 14%, although the design of the housing was not specified (Gregory et al., 1990).

#### During the Laying Period

It is not only during catching and transport that fragile bones may break. Investigations of hens from different systems have also discovered old, healed fractures, where calcium is deposited around the affected area (Butterworth et al., 1987). Although hens from conventional cages have a higher incidence of bones broken during depopulation, birds from perchery and free range systems tend to have more old fractures, particularly to the keel and furculum (Gregory and Wilkins 1991). The range of old broken bones reported for birds examined at the end of lay from 6 flocks housed in perchery systems varied from 11 to 30% and for birds housed in 7 free-range systems between 2 and 42% (Gregory and Wilkins, 1991). It is not clear at what stage in the laying cycle these old breaks occur, although a single

study indicated that the damage appeared to be inflicted after 45 weeks of age (Gregory and Wilkins, 1996). The general construction of multi-tier and perchery systems, including flight distance and/or angles between perches or tiers, may be important in relation to bone fractures in aviary systems. According to Scott and Parker (1994) there is an apparent threshold, at around 1.00 m, beyond which birds are less successful when negotiating between horizontal perches. It has been suggested that designs based on the birds' abilities to leap from one place to another are likely to improve bird welfare, and it was originally suggested that difficulties in landing properly on perches installed at high steep angles between tiers (distance only 50 cm) might be the main reason for the high incidence of bone breakage. A recent study of a perchery system seems, at first sight, to support this view, since Freire et al. (2003) found 73% of perchery birds had old keel bone breaks. However, Wilkins et al. (2004) dissected a total of 500 birds from 6 free-range systems and 4 single level NC systems and found a very high prevalence of old keel and furculum bone breaks in all flocks, ranging from 50 to 78%. These systems did not include the steep tiers of perches originally thought to be the cause of breakage. A further study (Defra project AW0223) that involved the dissection of 50 randomly selected birds from each of 36 flocks housed in single level alternative systems has shown similarly high levels of bone breakage. The percentage of hens with at least one break ranged from 30 to 82% across the different flocks, with an overall average of 60.2%. This same study confirmed that the damage occurred during the laying period, as no birds had broken bones at the end of the rearing period (Wilkins et al., 2004).

#### **4.6. Climatic and air quality effects on animal health**

##### **4.6.1. Temperature and relative humidity**

Thermoregulation in layers relies on several physiological mechanisms. Given that one of the hen's main defences against excess of temperature is evaporative cooling by panting, whose efficacy depends on the moisture content of the air, effects of temperature and relative humidity (RH) are not easy to separate, since a high air RH impairs adaptation of birds to high temperatures. Thus, the effects of air temperature and RH will be commented on together.

The thermoneutral zone for adult layers is wider than for pullets being reared, and it is estimated to be in the range of 12-24°C. Outside this range hens may adapt to temperatures to some extent by changing their behaviour and their feed (energy) and water consumption, and in the case of high temperatures, by increasing their dissipation of body heat by means of an increasing heat loss by water ingestion. When environmental temperature approaches body temperature (40.6-41.9°C) there is an increased risk of death of birds by heat stress.

Most of scientific references on heat stress in laying birds are quite old. However this problem is well known in commercial practice in the EU Mediterranean countries. Research, mainly performed in hot countries, has been concentrated on the study of physiological mechanisms and consequences, and on nutritional and husbandry solutions. Thermal stress has not been much studied from the welfare point of view, although due to their great effects on bird physiology and survival without doubt it can become a huge welfare problem.

When the temperature rises above the thermoneutral zone, hens' core body temperature increases, and birds try to gradually cope with heat by using several mechanisms of defence. The first one is to avoid if possible areas of excess temperature, which is not possible for birds kept in total confinement. Layers also increase heat loss by radiation and conduction using cutaneous evaporation (by use of air sacs), vasodilatation, panting and postural changes. Water consumption increases, and feed consumption decreases.

From 33-35C, heat loss by evaporative cooling with respiration becomes the main mechanism of defence; at 35C a 57% of body heat is lost by this mechanism, compared with only 10% at 5C. Cardiac and respiratory rates increases which supposes for the bird a great expenditure of energy (> 13%). Panting, which is a normal response, contributes to eliminate excess of body heat, but also produces important losses of water and CO<sub>2</sub>, which in turn can lead in birds to dehydration and physiological imbalance, as alkalosis (increase in blood pH). There is also an increase in excretion of urine and electrolytes, mainly potassium, phosphorus and calcium, leading to water balance distortion and negative balance to most electrolytes. If such situations are of great intensity and/or duration in time, in the end these defence mechanisms may lead to death of bird.

The consequences of heat stress may be reduction of body weight and bone mineral reserves, important decreases in number and size of eggs, poor shell quality (because of reduced calcium ingestion and absorption and respiratory alkalosis), with subsequent increase of cracked eggs, slower gut transit rate and impaired intestinal absorption and feed efficiency; also, wet faeces, causing dirty eggs, and wet litter in non-cage systems, and finally an increase of mortality. It also increases risks of feather pecking and cannibalism. Heat stress may promote a great rise in plasma corticosterone levels, decrease plasma thyroxine and triiodothyronine levels, and also impair immunity, in all cases to an extent that no other climate stressor can produce.

The effects of heat stress are strongly related to several endogenous and exogenous factors. Amongst the first ones are genotype, age of birds and feather cover. Differences exist amongst commercial hybrids, since those with a higher body weight/feed intake, and thus heat production, are more prone to heat stress. Young and old layers are both affected, but in different ways and, in general, the effects are worst in the onset of lay and in older birds. Lower body insulation because of less feather cover may help to cope with this situation.

Amongst exogenous factors, level and duration of temperature, previous thermal experience of birds, concurrence or not of other stressors, air speed, air RH, and stocking density can be cited. Layers can cope with increasing temperatures up to 28-32° C, but above this range the effect of heat stress increase exponentially. Hens may also cope more easily with cyclic temperatures than with (almost) constant high temperature, but the concurrent effects of other environmental stressors, such as dust, ammonia, noise or wet litter will aggravate the effects of excessive temperature. Acclimatisation to temperature during the rearing phase may improve physiological responses of birds. Evaporative cooling by panting is much less effective to dissipate heat when air water content is near to saturation, thus the effects of a high temperature with high RH are far more detrimental for bird health than those from a

higher temperature with a low RH. High stocking densities impair dissipation of heat and also imply a higher heat production inside the laying house, thus higher densities increase risks of heat stress.

Climate control in laying houses is of paramount importance to prevent heat stress in layers. Great improvements in ventilation and cooling systems have been made in recent years in some hot European countries. Thus the risk of heat stress in more temperate countries may sometimes be higher when a heat wave occurs (as in 2003), because of an insufficient preparation of laying climate control facilities to compensate for high temperatures.

There is little scientific information concerning effect of housing system on heat stress. The most studied subject is the effect of stocking density and design (solid or open mesh cage walls) in CCs. It is also known that layers housed in the upper tiers of cages may suffer more from heat stress than those housed in the lower levels. There have been anecdotal observations in a couple of experiments with FCs, where heat stress experienced by layers housed in FCs was lower than in CCs.

There is little information about heat stress in NC systems. In high density aviaries (up to 20 birds/m<sup>2</sup> of ground floor surface) potential problems could arise in hot European countries, unless ventilation systems for these facilities are improved; to date the using of this housing system is very limited in such countries. Layers housed in NC systems could be more or less affected depending on stocking density and the state of the litter, but less than in high density CCs, because of greater freedom of movement. In one experiment performed in India, layers housed in deep litter showed a greater level of plasma triiodothyronine and less reduction in total leukocyte count and also a lower increase in heterophyl/lymphocyte ratio than hens housed in CCs, suggesting that the latter suffered from a greater degree of stress. Moreover, layers which have access to outside runs have more possibilities of defence against excess of heat, if use of range is good (thus decreasing density inside the building) and shelter (shade), vegetation and drinkers are provided.

The opposite problem (cold stress) is far less important in practice, since layers may cope more easily with low temperatures, near to 0°C. However, this depends on plumage condition. There were occasional reports of reduced egg production and occurrence of frozen combs and wattles in layers housed at very low densities or on free range in countries with very low winter temperatures. Temperatures below the thermoneutral zone values are accompanied in many instances by high RH values, and if the ventilation is not adequate to eliminate the excess of humidity, this will settle onto the litter as condensation, causing wet litter and associated problems as footpad lesions.

#### 4.6.2. Dust

According to Koon et al. (1963) the bulk of the cage layer dust is flaky and cellular, consisting of skin debris interspersed with some food particles. Another common particle is broken feather barbules. In litter houses the dust also contains particles from the litter material and according to Grub et al. (1965) dust production by layers

on litter is a function of air moisture. The finding that dust levels dropped as air moisture increased supported this conclusion. According to Anderson et al (1966) the dust content of air in a poultry house increases with an increase in the activity of the birds. In a comparison of floor types in broiler houses Madelin and Wathes (1989) found higher dust concentrations and numbers of airborne micro-organisms in litter-floor houses than in those with netting floors. According to Hayter and Besch (1974) the largest dust particles (3.7 - 7 microns) were deposited primarily in the anterior portion of the respiratory system while the smaller particles (1.1 - 0.091 microns) were distributed equally throughout the rest of the system. The smaller particles are usually referred to as respirable dust (Donham, 1999). Particle size is of fundamental importance to the influence of dust, as with particles diameters of 4 to 5 micron the alveolar deposition rate may be as high as 50% (Hartung and Seedorf, 1999). Ellen et al. (2000) showed that techniques to reduce dust levels in poultry houses may effect total dust levels, but not respirable dust levels. This makes it important to take both total dust and respirable dust levels into account when studying the relation between dust and animal. Dust in a poultry house may serve as a pathogen disseminator and according to Wolfe et al. (1968) dust increased the number of turkey condemnations due to infections of the air sacs. Broilers on litter were also observed to have a higher incidence of lung damage than broilers on netting floors (Madelin and Wathes, 1989).

More recent studies to a great extent confirm earlier ones and are still valid for new systems. Thus, several new studies in large sized laying operations have shown average increases in dust levels of 5-15 times in aviary systems compared to cages (Tauson et al., 1992; Mårtensson, 1996; Michel, 2004). Tauson and Holm (2002 and 2003) reported moderate levels of dust over the year in 27 flocks on farms with furnished small group cages, i.e. in total variation 0.1-2.4 mg/m<sup>3</sup> with an average of 1.0 and 0.6 mg/m<sup>3</sup> for the two cages respectively. Few investigations on the respiratory tract as it is affected by dust levels are reported. However, recently Michel and Huonnic (2003) found, at the end of the laying period, that histology preparations showed pulmonary lesions of parabronchitis or interstitial pneumonitis, which were more extensive and severe in birds in aviaries (maximum dust of 25 mg/m<sup>3</sup>) compared to hens in cages (maximum dust 4 mg/m<sup>3</sup>). Saleh et al. (2003) found that total bacteria concentrations (cfu/m<sup>3</sup> x10<sup>6</sup>) in the air in an aviary, CCs and FCs in winter and summer time respectively were 2.16 and 0.56; 0.25 and 0.38; 0.39 and 0.12 i.e. significantly higher in the aviary system than in both CCs and FCs. Michel (2002) also showed that bacterial concentrations were 3.8 and 1.35 log cfu/l in aviaries and CCs respectively. Similarly Mårtensson (1996) reported significantly higher levels of endotoxine in the dust in a multi-tiered aviary system than in CCs.

#### 4.6.3. Ammonia.

There are few studies reported on the perception of ammonia in laying hens. However, Wathes et al. (2002) showed that when given the choice of selecting compartments with 0, 10, 20, 30 and 40 ppm NH<sub>3</sub>, birds choose the fresh air. Concentrations of ammonia are generally higher in housing systems with manure composting or open storage of slurry inside the house. Drost et al. (1995) found ammonia concentrations between 12.92 and 32.29 mg/m<sup>3</sup> in commercial aviary systems. The litter and manure handling methods as well as the temperature regulation of the house are probably of importance for the ammonia content in the air

of the poultry house. Anderson et al. (1964) noted that when the litter moisture content rose above 25% and the house temperature was above 16°C ammonia was present at detectable levels. Tauson and Holm (2001) reported ammonia contents over the year in a FC house at 1-2 ppm and in a parallel single level NC system with slatted floor and manure storage system at 5-40 ppm. This is in accordance with findings of Van Emous et al. (2003) who reported NH<sub>3</sub>-concentrations in hen houses with small-furnished cages to be 0.96 ppm on average and for large FCs to be 1.37 ppm on average. In single level NC systems with manure storage, Reuvekamp and van Niekerk (1996) found concentrations of 16.3 ppm NH<sub>3</sub>. When using a litter drying system in a tiered wire floor aviary, Groot Koerkamp et al. (1998) found a low concentration of ammonia (5 ppm) in the exhaust air.

Ammonia concentrations above approximately 25 ppm (Marthedahl, 1980) may have an adverse effect on the health and production of poultry. According to Marthedahl, young animals are more sensitive to ammonia than mature animals. The main clinical symptom caused by ammonia is kerato-conjunctivitis involving damage to the cornea and conjunctiva. In broiler chickens gross and microscopic lesions in air sacs were observed as early as 12 hours post-exposure in birds exposed to 100 ppm ammonia alone or in combination with either *E. coli*, dust or both (Oyetunde et al., 1978). Ammonia damage in the early life of pullet chicks may have a lasting adverse effect on them as laying hens. Charles and Payne (1966) found that White Leghorn pullets exposed to ammonia levels as high as 78 ppm during the 11 to 18 week growing period showed an increase in the number of days taken to reach 50% production, and a reduction in hen-day egg production. According to Marthedahl (1980) kerato-conjunctivitis may be seen in birds kept on litter as well as in birds kept on wire. Madelin and Wathes (1989), who found no differences in the concentrations of gaseous ammonia between litter and netting floors in broiler houses, confirmed this observation.

#### **4.7. Mortality**

Animal welfare has been often assessed through the measurement of production performance and mortality, especially by producers. In the best-managed efficient modern systems, with the exception of unexpected events, performance is maximised and mortality rate is at low levels. Consequently, it may be forgotten that survival is a pre-requisite of all considerations regarding welfare. On the other hand, although mortality remains a very objective criterion of welfare, it is not sufficient in itself and a low level of mortality does not necessarily indicate a good level of welfare. However, a sudden increase in mortality usually indicates a welfare problem (Blokhuys and de Wit, 1992) and should be carefully considered.

Infectious and production diseases as well as injury affect hens' health, leading to mortality, which can be an overall assessor of the health and welfare of the flock. Any assessment of new housing systems has to include mortality rate as indication of welfare.

There have been many studies on mortality in relation to housing systems during the last 10 years. However, few have been conducted in comparable conditions. Several factors affect mortality rates. Disease risk, pecking and cannibalism, and poor management all contribute, as does genotype. The possibility of using veterinary

treatments also differs between countries regarding the withdrawal times of eggs, which affects bird health and production.

It is difficult to make general conclusions concerning the studies undertaken to assess the influence of keeping systems on laying hen mortality. Thus, as no study compares all the cages and NC systems under the same conditions, it is very hard to give a hierarchy, in terms of mortality, among all the existing systems. However, by reviewing the most recent data from numerous studies in both field conditions and in experiments, it is possible to detect some clear trends.

Since 1996 numerous studies have been undertaken: Experimentally, CCs were compared to FCs (table 1.1) or NC systems (table1.3) or different models were compared with each other (table 1.2). In commercial conditions FCs and NC systems were studied, sometimes in comparison with CCs (table 1.4 and 1.5).

Abrahamsson and Tauson (1997) found lower mortality in small FCs (1.4-3.2%) than in CCs (3.9%). Very few studies compared FCs and NCs systems. In a large survey of egg producers in the UK, undertaken in 2003 on beak trimmed birds, mortality rates were 5% [2-8%] in conventional cages, 8% [3-12%] in barn and in free range (NFU, 2003). Other example is an experimental study with beak trimmed birds with CCs (6.8% mortality), large FCs (3.5% - 5.5% mortality) and aviaries (9.3% mortality) (Zoons, 2004). Weber et al. (2003) compared the mortality of Lohmann Silver hens in CCs (11.0%), FCs (8.7%) and in aviaries (11.7%).

The rate of mortality is mainly influenced by beak treatment, lighting, genotype and management, as well as the differences between housing systems.

The hybrid used may influence the results in different housing systems. White non-beak trimmed hybrids showed lower mortality rates in aviaries than brown hybrids (Wahlstrom et al., 1998a and 1998b; Tauson et al., 1999). When comparing several hybrids in FCs, some authors showed higher mortality rates with certain genotypes, even when the overall mortality was lower in FCs: this may have been affected by cage design. Cepero et al, 2000b and 2001b found for one brown hybrid 10.7% and 5.8% for CCs and FCs respectively and 15.1% and 10% for another brown hybrid. In the above mentioned Swedish field study brown hybrids tended to have higher mortality than white hybrids (Tauson and Holm, 2002 and 2003).

#### **4.7.1. Furnished cages**

Under experimental conditions, when some parameters vary, mortality can range from very few to more than twenty percent, although the latter figures are very occasional and could be explained by sub-optimal design or conditions. When compared to CCs, FCs can show similar mortality (Tauson and Abrahamsson, 1996; Wall et al, 2002, table1.1) or lower mortality with beak trimmed (Guesdon and Faure, 2004; Cepero et al, 2000b and 2001b; table 1.1) or non-beak trimmed hens (Abrahamsson and Tauson, 1997; table 1.1). When birds are not beak trimmed, the risks of cannibalism and mortality increase and could lead to very poor welfare: Guémené et al, (2004) found in two models of standard cages 51 and 52% and in FCs 36 and 43% of mortality which were significant differences. In beak trimmed

animals of the same study, mortality stayed under 7% in both systems. When a cannibalism outbreak is happening, the increase in mortality appears in FCs (as shown above) as well as in CCs: such as obtained by (Hartini et al., 2002) (0.77% mortality for beak trimmed hens and 37.7% for non beak trimmed ones, from 21 to 24 weeks). When there was no cannibalism the differences were usually small between beak trimmed and non-beak trimmed birds: in CCs such as obtained by Michel and Pol, 2001 (1.9% for beak trimmed birds and 2.8% for non-beak trimmed ones; significant difference) and in FCs (Van Emous et al, 2003, 5% for beak trimmed animals and 5.4% for non-beak trimmed ones, table 1.2).

Variations in mortality are not always easy to explain. Beak treatment can play a role as well as lighting (Elson, 2004; Van Emous et al, 2003, table 1.2) with important differences in mortality with light colour and intensity. But, as we can see from table 1.2, in the same experimental conditions, mortality can vary considerably from one trial to another, greatly increasing or decreasing the rate of mortality as well as the differences between beak trimmed or non trimmed birds and different lighting regimes. Concerning cages, mortality may sometimes be decreased by furnishing the cages (Guesdon and Faure, 2004) but not always or by decreasing the size of the group (Appleby et al., 2002) but not always (Abrahamsson and Tauson, 1997). For instance, (Appleby et al., (1993) obtained mortality of a maximum 1.6% with non-beak trimmed ISA Brown hens kept in both CCs and FCs.

Under commercial conditions, the introduction of small FCs in Sweden, 8 or 10 birds/cage, since 1998 has resulted in mortality rates in 38 flocks with non-beak trimmed hybrids at an average of 5.1% (Tauson and Holm, 2002) and 6.5% mortality (Tauson and Holm, 2003) respectively, which is comparable with mortality in CCs (table 1.4). In this country, there are about 1.8 million hens in FCs, at the moment which account for about 30% of the national flock. An English study showed mortality rates under 4% in FCs for 8 to 20 hens (Elson, 2004; table 1.4). Commercial results, available up to now, did not involve cannibalism and showed low mortality rates, even with non-beak trimmed hens. Recent results from a large German survey of commercial flocks also showed mortality rates averaging  $5.2 \pm 2.2\%$  in a variety of designs and group sizes of FCs (10-60 birds/cage), with beak trimmed and non-beak trimmed birds of various genotypes as compared to the breeders standards of 5.1% mortality (Rauch., 2004).

#### **4.7.2. Non cage systems**

Under experimental conditions (table 1.3), it was shown that mortality can vary considerably with the hens' genotype, beak treatment and between flocks. For instance, Abrahamsson et al. (1998) carried out a study over six years (5 trials) with the Marielund three-tiered aviaries and showed variations in mortality from 3.4 to 7.8% among trials, with increasing mortality of 15.6% and 20.9% in certain pens.

In studies comparing NC systems and CCs the mortality is often lower in cages (Tauson et al. 1999; Koelkebeck and Cain 1984; Wahlström et al. 1998a and b). Tauson et al. (1999) showed that in Lohmann brown (LB) non beak trimmed hens there was significantly less mortality in cages (7%) than in floor or aviary systems (21-27%), whereas with white Lohmann selected leghorn (LSL) hens there was no

significant difference (6-10%). Wahlstrom et al. 1998b also showed very important variations in mortality when using two different genotypes: in 2 models of aviaries the authors showed that mortality was higher for LB (45.3% and 30.2%) than for LSL (4.9% and 3.1%). This difference between LSL and LB hybrids was also shown in other studies (Wahlstrom et al. 1998a), underlining the importance of the suitability of the hybrid to certain housing systems. Some authors showed in 6 flocks that mortality in aviaries was below 9%, even when hens were not beak trimmed (Michel and Huonnic, 2003, Michel and Pol, 2001 and Michel, 2004).

Under commercial conditions (table 1.5), surveys assessed the influence on mortality of different models of NC systems in 17 (Ekstrand et al, 1996) to 71 (Jensen, 2003) non-beak trimmed flocks. Mortality was generally higher than those obtained for cages in commercial operations. Average mortality ranged between 8% (Tauson and Holm, 1999) and 15.8% (Ekstrand et al, 1997) in different designs of aviaries. Among five identified surveys, one was undertaken with beak trimmed hens (Jensen, 2003) comparing CCs to floor and free range systems. The lowest mortality was recorded in CCs (5.1% [4-6.3%]), while floor systems (9.9% [8.7-12.1%]) and free range (9.5% [7.7-11.4%]) revealed higher rates. However no flock had more than 12.1% mortality. In the other surveys (Ekstrand et al., 1996 and 1997, Tauson and Holm, 1999 and Jensen, 2003) mortality reached 23, 27, 25 and 18.4% in some flocks (the latter being an organic flock).

In 2001 and 2002, mortality was calculated on French farm results (ITAVI, 2002; Magdelaine and Mirabito, 2003). The sample involved 48% of hens kept in CCs (18 millions hens), 43% of free range, 94% of organic and 42% of floor systems. The mortality in these housing systems was, respectively for 2001 and 2002: 5.3% and 4.9% for CCs, 11.7% and 14% for free range, 14 and 13.9% for organic farming and 11.6 and 7.5% in single level NC systems. Thus, NC systems in this study showed higher mortality in beak trimmed birds (often >10%) than CCs.

At high temperatures, FCs and NC systems allowed more space for hens and therefore provided conditions that resulted in a lower mortality rate than in CCs, in particularly hot climatic conditions (Guesdon and Faure, 2004; Cepero et al, 2000b; Michel, 2004). However, in these studies the climatic circumstances were exceptional and the environmental control systems were inadequate.

Tables of Mortality: see appendix at the end of this report.

#### **4.8. Risk associated with veterinary medical products**

Risks due to veterinary drug residues in eggs also should not be increased in FCs over CCs, since in several scientific reports there is no reported effect of type of cage on laying hens pathologies other than (in some cases) feather pecking and cannibalism.

There are a number of potential chemical hazards that may lead to egg contamination:

- a) Use of antimicrobials and anthelmintics:

Antimicrobials are used in poultry flocks mainly to control bacterial diseases, and in some circumstances, they are used to try to eliminate *Salmonella* spp. infection in commercial pullets mainly during the rearing period. Whatever the use, the treatment should be applied following veterinary instructions and the eggs should be withdrawn during the legal “withdrawal period” attributed to each product to avoid the presence of residues.

Anthelmintics will be used to combat infections with parasites (helminths). EU or national legislation strictly regulates the use of both groups of veterinary medical products.

b) Use of coccidiostats in young non-laying poultry:

The use of coccidiostats as feed additives to young poultry is strictly regulated. The use in adult egg laying hens is not allowed and no Maximum Residue Limits (MRL according to Council Regulation 2377/90/EEC) values in eggs have been set. The occasional occurrence in eggs is mainly due to carry over in feed mills or during transport of the feed from a dosed batch to the next (clean) one. Most coccidiostats will be deposited in eggs (Kan, 2003) and detected by modern analytical techniques at rather low levels.

In theory, these hazards may be more prevalent in eggs produced in NCs, due to the reported higher incidence of bird pathologies, especially parasitic infestations. Recirculation of unwanted substances like drugs or coccidiostats via contact of the animals with their excreta is also more likely to occur in eggs produced in them (Friedrich et al., 1984).

The frequent reports of higher disease incidence in NCs, in particular those caused by parasites (Wegener, 2002), implies that there is also a higher risk of undesirable residues in the egg contents, especially those of antiparasitic drugs (Kan and Brambilla, 1993; Kan, 1995). The available information on the results of residues control in the Member States, as required by Council Directive 96/23/EC, does not allow to establish a conclusion that supports such a hypothesis, since the origin of the non compliant samples does not appear in the official report transmitted to the Commission. Also, differences occur among European countries in the priorities for detection of certain substances. The permitted use of certain drugs per se against parasitic infestations like worms also differs between countries, as well as the applicable withdrawal time of eggs for consumption (Veterinary Medicines Directory, 2004).

Control by Member States in place as required by Directive 96/23. Data shows the risk managers to follow up on this.

The data from 2001 and 2002 European reports based on the control programs according to Council Directive 96/23/EC indicating sampling, methodology etc. (Council Directive 96/23/EC) on food residues show that 43% (51% if nitrofen-positive eggs are excluded) of the non-compliant egg samples all over Europe contained residues of anticoccidial drugs, and increased by a 30% in 2002. The control programs are of a targeted nature, as required by EU Council Directive, so any increase can also be due to better targeting towards suspect samples. Furthermore, new subatomes might have been added to the control program

introducing another bias in judging a possible increase. The authors of most publications argue that cross-contamination of feed in the feed mill or during transport is the major contributor to this increase. However, these figures (56 positive samples) seem to be too high to support this explanation without considering other reasons. Anticoccidial drugs are not needed in the cage housing system. Anticoccidial drugs residues were mainly found in eggs from Austria and the United Kingdom in 2002, countries having a high percentage of layers in NCs, but in others such as Denmark, Germany or the Netherlands these findings were scarce. Usually, however, the birds acquire resistance towards coccidia in early life and most coccidiostats only prevent coccidiosis and do not cure it. Thus administering coccidiostats to laying hens is not a regular or useful practice. In France 6 egg samples (66% of their non-compliant samples, around 0.6% of total number of samples) showed residues of nitroimidazole, a drug against *Histomonas* parasites. In Italy 5 egg samples (42% of their non-compliant samples, 0.9% of total samples) showed residues of anthelmintics, drugs that are only needed in the floor systems.

These data suggest an increasing presence of anti-coccidials drugs in eggs in some EU Member States between 2001 and 2002. This increase may be due to increase of layers in NCs, more targeted sampling of suspicious lots, and more sensitive control methods. In contrast, residues of antibiotic drugs in eggs are more often found in countries having few layers in NCs, such as Spain or Italy, and (maybe) Belgium. The figures for residues of antibiotics in 2001 were 37.5% of the non-compliant samples and in 2002 were 8.9%. The causes of this annual variation and differences between Member States should be investigated.

## 5. PHYSIOLOGICAL INDICATORS AFFECTED BY SYSTEMS

One method that can be performed to investigate how chronic stress is linked with housing conditions is the ACTH challenge (Thorn et al., 1953). This test involves measuring the adreno-corticotrophic axis sensitivity and maximal reactivity (Landsberg and Weiss, 1976; Mormede, 1988; Janssens et al., 1994; Guémené et al., 2001). For instance, Koelkebeck et al., 1986 used the ACTH challenge as an indicator of the level of physiological stress response of laying hens in several housing alternatives. The authors showed that the use of a submaximal dose of ACTH (0.33 UI/kg) instead of a higher one tended to be more effective to assess management differences (cages of 3, 4 or 5 hens; floor hens (0.094-0.373 m<sup>2</sup>/hen). In cages, corticosterone responses of hens in the biggest group (5 hens) were greater than the other cage treatments. Hens kept on the floor, at the higher density, produced more corticosterone than little group caged hens.

Craig and Craig, 1985, showed influence of handling and confinement on corticosterone level. But neither housing conditions (floor vs cages) nor genetic stock differences were found for plasma corticosterone level. Guesdon et al, 2004 didn't show any difference in the level of corticosterone, after an ACTH challenge, in hens housed in four different cages models (two conventional and two furnished). On the other hand, Guémené et al., 2004 in a subsequent study showed an higher sensibility (submaximal dose) in hens kept in furnished cages at a lower density (>1000cm<sup>2</sup>/hen) than hens kept in an other model of furnished cage at a higher density (750cm<sup>2</sup>/hen) or conventional cages (600cm<sup>2</sup>/hen). The authors suggested that these results indicated chronic stress in birds at the lowest density. Craig et al, 1986 assessed physiology and three other welfare criteria on hens of four genetic stocks kept in each of four laying hen environments. Differences between strains (selected for increased egg mass or not) were not detected, neither were interactions with housing. However, corticosteroid concentration was higher in floor penned and high-density caged animals than in single hen low density cages and 4-hen moderate-density cages.

Mortality was higher and egg mass per hen housed was less in the 6-hen cages than in floor pens, single-hen cages and 4-hen cages, during the 40 week period following housing. In this study, plasma corticosteroid concentrations did not yield results consistent with other criteria of hens welfare. There is still a need to look beyond the results of corticosteroid assays in establishing hen's welfare in widely different environment.

Some authors used the level of corticosterone, without ACTH stimulation, to assess the stress after 48 or 96h of housing in cages with different stocking densities. Mashaly et al. (1984) showed corticosterone concentrations consistently higher in the serum of birds housed five per cage than in birds housed three or four per cage.

Adrenal gland weight has frequently been used as a stress indicator with light weight in chronically stressed birds. However, it is an invasive method and, although it is easier to collect in immature animals, it is quite difficult for the one which is located in the left ovarian stalk in mature females. Old studies (Siegel, 1959 and 1960) showed that enlarged adrenal glands are associated with high density housing conditions.

Chronic stress can be assessed by measuring antibody titres for a specific immunogen. Differences in the maximum response and the pattern of change were recently reported for laying hens kept in various cage types (Guémené et al., 2004; Moe et al., 2004). However, these differences were related to beak trimming with an indication of a lower stress state in beak trimmed hens (Guémené et al., 2004) or initial rearing conditions (Moe et al., 2004). Therefore, these authors underlined that validation of this indicator as well as knowledge of the exact animal background is necessary before being able to draw any firm conclusions.

Due to difficulties to interpret a single physiological measure the better way to assess chronic housing stress is to use several physiological, behavioural and productivity indicators. El-Lethey et al. (2000) used production measures, tonic immobility, H/L ratio, different antibody production and feather pecking to assess the welfare of hens provided with two feed types and with or without straw. The results tended to vary in the same way as production and tonic immobility, and indicated more stress when no straw was provided and when feather pecking was higher.

Another study (Barnett et al, 1994) used behavioural, physiological and production indicators to assess the impact of increasing human contact on animal welfare. Compared with “minimal” treatment, increasing the amount of human contact reduced the level of fear of humans showed by birds, on the basis of their withdrawal responses in two behavioural tests and decreased corticosterone response to handling, with consequent effect on production. The mechanism may involve a chronic stress response since adverse changes in cell-mediated immunological responsiveness were found in the “minimal” treatment. The results indicate that human contact may be an important determinant of bird behaviour, production and possibly welfare.

A recent study on the effects of stocking density and cage height on fear and distress in laying hens housed in furnished cages was undertaken on four flocks, using “approach/avoidance” to novel object test, tonic immobility and H/L ratio as indicators (Jones et al, 2004). Generally, the authors found that fearfulness and distress were not affected by variations in cage height, the bank in which the cage was situated, or stocking density. Differences in fearfulness were found between cage models, though H/L ratios were not affected. In a study of Guémené et al. (2004) corticosterone measurements, H/L ratio and antibodies production in response to immune challenge showed that stress levels might be higher in FCs having a larger group size than in CCs and in non beak-trimmed (because of a cannibalistic outbreak) than in beak-trimmed hens in these experimental conditions.

## 6. PRODUCTIVITY RELATED TO SYSTEMS

The egg production of many hybrids has been improved by genetic selection and management changes over many years, at a rate of about three eggs per hen per year, and is now at an all-time high (Elson, 2002). Mean egg weight has also increased so that egg mass output per hen is now also very high. At the same time feed intake has tended to fall, resulting in superior feed conversion efficiency. Such high levels of performance are unlikely to be achieved unless hens are in good health. On the other hand, an extremely high level of production might predispose the hen to production diseases and hence poorer welfare.

As indicated in the 1996 report a problem in using productivity as a measure of animal welfare is that we generally measure the productivity of the flock but are concerned about the welfare of individuals (Duncan and Dawkins, 1983). Also production records are often analysed in respect of physical or economic return, which throw no light on bird welfare. According to Adams and Craig (1985) economic aspects of productivity should be considered separately from biological characteristics and only the latter taken as being relevant to welfare.

Systems of production e.g. CCs, FCs, aviaries, other indoor NC systems and free range are not easy to compare on the basis of productivity because usually several variables are involved. For example, each system being compared would often be in a different house.

Whilst production has been recorded in many studies within systems, not many studies have been conducted covering a wide range of systems. However, some recent trials and surveys involving at least two systems providing productivity data have been reported. Examples are:

- In Sweden Tauson and Holm (2001) compared two parallel flocks in single level NC systems and FCs and found 3% lower egg mass and 4% higher feed conversion rate in the NC system.
- In Germany, Leyendecker et al (2002a) compared the performance of hens reared together, housed during the laying period in CCs, FCs and an aviary. Eggs collected were highest in the FCs and lowest in the aviary. Feed conversion ratio was better in cages than in the aviary.
- In France, Michel and Huonnic (2003) compared CCs with aviaries. More eggs were collected from the caged hens than from those in the aviary, and the former had a superior feed conversion ratio.
- In the UK the National Farmers Union regularly conducts surveys among their members. In a recent survey of many producers with flocks housed from 17 to 72 weeks of age (NFU, 2003) they reported the highest eggs collected in CCs – a mean of 307 eggs/hen (range 290-329) followed by single level NC systems, with a mean of 298 eggs/hen (range: 260-311). Mean feed intake was CCs 117: g/bird/day, alternative indoor: 124g/bird/day and free range: 128 g/bird/day.
- In Belgium, Zoons (2004) compared CCs, large group FCs and an aviary. The highest number of eggs was collected in FCs, followed by CCs, and the lowest was in the aviary.

When interpreting these results it should be remembered that misplaced and broken eggs can distort the picture. Thus caged and free-range hens might lay the same number of eggs per hen over a given period and therefore biologically have equal performance. However, the cage eggs might all be collected whereas a fair proportion of the free range ones might be laid away from the nest boxes and broken, eaten or otherwise lost. The appearance, and economic effect, would then be one of superior productivity from the caged hens when, in fact, both could be biologically equal. It is also important to take into account how the birds are reared for these different systems. For example, birds may find food and water more quickly in cages than in NC systems. The effect of this may be seen in lower egg output or in dehydration and/or emaciation of birds, especially in the first weeks of lay. Furthermore plumage condition can affect feed efficiency.

Within flocks, productivity can be a useful parameter to use in maintaining bird welfare. Thus, for example, if a particular cage were deprived of water the problem, which would quickly become a welfare one, would soon show as a drop in egg output. This would draw attention to the problem, which might be hard to detect in a large house in other ways, and its solution would rapidly benefit hen welfare. So low production, and especially a sudden drop in productivity, can be an early indicator of impaired welfare and resolution of the problem can lead to the alleviation of suffering.

## **7. BEHAVIOURAL PRIORITIES**

### **7.1. Egg laying**

The conclusion in the 1996 report (SVC/EC 1996) that “Laying hens have a strong preference for laying their eggs in a nest and are highly motivated to perform nesting behaviour” is supported and even strengthened by research since then. Techniques for measuring motivation have developed rapidly over the past 10 years and it has been possible to quantify this motivation using operant techniques. The motivation to get access to a secluded nest site to lay an egg has been measured by how hard a bird will push through a small opening and has been estimated to be higher even than the motivation to feed following 8hr food deprivation (Cooper and Appleby, 1996). In a later study, (Cooper and Appleby, 2003) it was shown that motivation to get access to a nest was equivalent to 4 hours of food deprivation 40 minutes before expected time of egg laying and 4 times greater than that 20 minutes before egg laying. Thus motivation to get access increases closer to time of oviposition.

Recent work also supports the earlier claim that nesting motivation consists of the motivation to find a nest site and the motivation to build a nest, and that these can be quantified separately. For example, with regard to nest searching, birds were motivated to squeeze through a narrow gap in order to get access to a ring shaped pen in the pre-laying phase. This motivation was highest for birds with no discrete nest site in their home pen, less for birds provided with a semi-enclosed nest site and least for birds with a wooden enclosed nest site (Freire et al., 1996). The conclusion is that not only do birds show a preference for laying their egg in a nest, but that the provision of an enclosed nest site reduces motivation for nest searching. With regard to nest building, then work interrupting pre-laying behaviour, for example by providing food (Freire et al., 1997) or delaying access to nest sites (Cooper and Appleby, 2003), suggested that it is important for birds to spend some time on nest-building prior to egg laying. In the experiment referred to earlier by Cooper and Appleby (2003) birds prevented from access to a nest 40 minutes before the expected time of lay still laid their egg at the predicted time. But time of oviposition was delayed in birds prevented access to the nest only 20 minutes before the expected time of egg laying. Researchers interpreted this delay as being caused by the high motivation of the bird to perform nest building. Thus it can be concluded that egg laying behaviour, like nest searching behaviour, is a behavioural priority for laying hens.

All the above research has been carried out with single birds working to get access to a single nest. There is a lack of research on motivation to get access to colony nests and in groups of birds. It is not clear, therefore, whether nests - presented as they usually are under commercial conditions - would be equally successful at reducing the motivation for nest searching. Neither has there been recent work on how the motivation to perform nest building is affected by the type of nest. It has long been known that the presence of loose material in a nest is attractive, although work suggested that access to a pre-moulded nest was acceptable as long as it allowed the performance of nest building behaviour (Duncan and Kite, 1989). On well-managed farms under commercial conditions, Astro-turf or pre-moulded nests are used by the birds. However, choosing a particular nest site only means that it is

preferred to other potential sites in the system and not necessarily that it satisfies egg laying motivation. Likewise, we can not conclude that because birds show nest building behaviour in the absence of loose material that their nest building behavioural priority is satisfied. Birds showing nesting behaviour in the absence of litter may be likened to birds showing dustbathing movements in the absence of litter and, as yet, we do not know the extent to which these sham activities satisfy the needs of the birds.

The importance of an appropriate nest site seems to be independent of prior experience of egg laying (Cooper and Appleby, 1995). This might be expected considering the survival benefits for the chicks and thus the evolutionary pressure to "get it right" even with the first egg, but there does seem to be individual variation. Even when attractive nest boxes are provided, some birds lay their eggs outside the nests (Sherwin and Nicol, 1993a) and this begs the question of whether or not this is a welfare problem for these hens. The answer will depend on why the hen did not use a nest. If the hen is motivated to lay in a nest, but can not find what to her is an appropriate site and so, as a last resort, lays in an inappropriate place, then it probably is a welfare problem. To this bird, there is no nest. However, if she chooses to lay her egg outside the nest box provided because she perceives the place she selects as the most appropriate, or she lays outside the nest because she is not motivated to lay her egg in an enclosed area, then it probably is not a welfare problem. There is some evidence that some individuals are genuinely less motivated to gain access to nest boxes (Cooper and Appleby, 1996), which may imply relaxed selection pressure on nest site selection in commercial strains of birds. This is difficult to confirm since strain is often confounded with rearing. There would need to be more research before it could be confirmed that this difference was attributable to a genetic difference in motivation to reach the nest and not a genetic difference in ability to reach them. For example it is well documented that early access to perches decreases the number of floor eggs (Appleby et al. 1988; Gunnarsson et al., 1999).

An alternative view, which has not been investigated further since the previous report, is that rather than commercial designs of nests being inadequate, they are actually superstimuli (Appleby and Mc Rae, 1986). Under conditions where all nest boxes are much better than what would usually be available in the wild, the problem to a bird becomes in which nest to lay its egg. Such a view would be in keeping with the fact that most eggs are laid in nests that are easy to locate or are in some way different from the others e.g. located at the end of a row. Birds have been shown to prefer a nest site that already contains an egg and significantly fewer birds laid their eggs during an observation period when eggs were removed (Lundberg and Keeling, 1999) which may be a response to perceived predation on the egg. Thus hens may be attempting to express choice even when given many potential sites. That birds can delay egg laying if disturbed was mentioned earlier as an indication of the importance of laying in a suitable nest site, but this may have consequences for shell quality. The severity of the shell defect varies, but after a major stress event it is estimated that it takes 2-3 weeks for the oviduct to recover (Solomon, 2002).

It has been proposed that laying eggs outside the nest box may predispose individuals to vent pecking, but this has not been confirmed. There was no correlation between mortality due to cloacal cannibalism and number of floor eggs in an epidemiological study (Gunnarsson et al., 1999), although Pöttsch et al. (2001)

found a significant relationship between vent pecking and whether or not light was used in the nest box. Abrahamsson and Tauson (1997) found both a high floor egg incidence and a high degree of cloacal pecking in medium heavy hybrids in aviaries, but this does not necessarily imply a causal relationship. Exposure of the cloacal mucosa may be more obvious in birds just starting to lay or laying an especially large egg, plus there may be a higher risk of mucosal injuries, both of which might attract pecking to the cloaca from a neighbouring bird. There is a strong probability that cloacal cannibalism is in some way at least indirectly associated with egg laying. It is noteworthy that under natural conditions a bird separates itself away from the flock to lay its eggs, whereas under commercial conditions birds are gregarious during egg laying.

## **7.2. Drinking, feeding and foraging**

Domestic fowl are omnivores and have retained the typical feeding pattern of jungle fowl, which consists of pecking and ground-scratching and manipulating with the beak (pulling and flicking), followed by ingestion. Although the degree to which pecking and scratching behaviours have been retained varies among strains of hybrids, they are still present and if frustrated these behaviours may be re-directed towards injury to or even cannibalism of flock-mates. With more than 30% of the time budget spent feeding and foraging, these are highly time consuming behaviour patterns during the day in laying hens.

In the SVC/EC 1996 report the following conclusions are formulated concerning drinking, feeding and foraging:

Laying hen should have at least daily access to food and access to water at all times.

Hens have a strong preference for a littered floor for pecking, scratching (and dust-bathing). When litter is provided it should be maintained in a friable condition. The provision of litter can reduce the risk of feather pecking.

With regard to drinking even if nipples do not seem to allow the normal drinking pattern there is little or no evidence that this could be a problem for laying hens which have been prepared for this type of drinker during rearing. In spite of that it may be of some interest to consider the findings of Green et al (2000) who associated the use of bell-drinkers with an increased risk of feather pecking. It was suggested that the reason for this result may be wet litter under the drinkers. Clean and fresh water has of course to be provided ad libitum.

Feeding troughs: In order to ascertain the degree of simultaneous feeding in two types of laying hybrids with different weights, feeding activity was recorded in 29 cages populated with four hens each with a feeder space of 12 cm per hen (Knierim, 2000) In all cages, the lighter and apparently slimmer LSL-hens (Lohmann Selected Leghorn, white) were able to feed simultaneously. However, for the somewhat heavier and apparently broader LT-hens (Lohmann Tradition, brown) this could not be observed in two of 16 cages. Nevertheless, the average proportion of cages was higher in LT-hens in which synchronous feeding of all hens could be noted at least once within each 30 minutes observation period. Simultaneous feeding of all laying

hens may be a behavioural priority in small groups but probably not in larger flocks fed *ad libitum*, where subgroups of birds can feed together. Experience in Switzerland with 8cm per hen showed that feeding space may be reduced in larger flocks, without causing the birds harm. Faure (1986) observed that groups of 4 hens only rarely worked to obtain more than the 40 cm length of feed trough and concluded that there was no necessity to offer a larger feeder space. Although the 'efficiency' of eating (g/peck) was not impaired significantly at low illumination, hens showed a clear preference for and appeared motivated to eat in bright as opposed to dim light (Prescott and Wathes 2002).

Exploratory behaviour and information gathering has been vital for survival of birds. Foraging – a most important part of the exploration behaviour - includes walking, scratching, stepping back, pecking and manipulating and is one of the most time consuming behaviours even in housing systems where the food is provided *ad libitum* in food troughs. Dawkins and Hardie (1989) estimated the need of space for ground scratching as 856cm<sup>2</sup> (range 655-1217cm<sup>2</sup>) per hen. Carmichael et al (1999) showed that birds spent most time on the perch frame (47%) but also 23% in the litter area. Individual birds were seen to use about 80% of the pen volume available to them. This value was similar for all densities and showed that individuals did not have separate home ranges.

Foraging is also a key behaviour which helps to minimise feather pecking and cannibalism as many investigations have shown e.g. the following epidemiological studies where “an absence of loose litter at the end of lay” (Green et al. 2000) and “Pennsylvania systems (without litter or less than 20% of the surface with litter) versus deep litter and aviaries” have been detected as risk factors for feather pecking. The results of Gunnarsson et al (2000a) imply that even if a substrate is not suitable for dust-bathing, caged laying hens have still a high demand for this litter substrate, presumably for foraging behaviour. In fact it is suggested that not only the quantity but also the quality of foraging behaviour elicited by a given material may be important to prevent the development of feather pecking (Huber-Eicher and Wechsler 1998).

The importance of the availability of litter during rearing was demonstrated in a study by Huber-Eicher and Sebö (2001). In aviaries, under commercial conditions, early access to a litter substrate has a significant effect on the development of feather pecking. Nicol et al (2001) reported comparable results from a study where from days 1 to 210, 144 laying birds were housed in pairs in pens with wire floors. The floors were replaced with solid floors covered in wood shavings at different ages and for different durations by allocation to 1 of 12 treatments. Adult birds that never experienced shavings performed significantly more feather pecking than birds in any other treatment group.

### **7.3. Comfort behaviours**

#### **7.3.1. Dustbathing**

The conclusion of the 1996 report was that “Hens have a strong preference for a littered floor for pecking, scratching and dust-bathing”. That part of the conclusion

referring to dustbathing behaviour was based on a large body of research (see review of some of that work by van Liere, 1992). Research since 1996 confirms the fact that birds have a strong preference for dustbathing in litter, but it has raised the question how to provide a littered floor in practice in a way that satisfies dustbathing motivation.

Sham dustbathing is not seen in loose housing systems, but birds frequently show sham dustbathing on the wire floor in cages, despite having access to a dustbath (Lindberg and Nicol, 1997; Olsson and Keeling, 2003). One view could be that sham dustbathing is functionally relevant, that is to say, it satisfies the motivation to dustbathe. If this interpretation is correct, then it might be argued that dustbathing in litter is not a behavioural priority. The alternative interpretation is that the dustbath provided in the types of FCs used in these studies was not adequate or not well placed. In this case dustbathing in litter may still be a behavioural priority. Unfortunately there is no clear answer to this question, although it has been shown that dustbathing on wire does not reduce the motivation to show dustbathing in litter (Lindberg, 1999; Olsson et al., 2002a) which would seem to argue against sham dustbathing satisfying birds' behavioural priority to dustbathe.

One of the problems when carrying out research on motivation to dustbathe is that it is very difficult experimentally to separate motivation to dustbathe from motivation to peck and scratch in the litter, which is why these behaviours were addressed together in the conclusion of the previous report. One approach to this problem has been to prevent birds from dustbathing, while still allowing ground pecking and scratching, by placing dowling rods above the litter (see Olsson et al., 2002a for a description). However, as yet there is no method of preventing ground pecking and scratching while still allowing dustbathing in the litter. Another approach has been to produce demand curves of how hard birds will work to get access to litter, separated according to what behaviour the bird performed when it got access. Matthews et al. (1995) found that although the demand for litter, irrespective of the type of litter, was similar when the birds pecked and scratched in it, the slope of the line for dustbathing in sand was less than that for dustbathing in wood shavings, implying that birds were more motivated to dustbathe in sand. It is already known that birds prefer sand, but what is interesting is that this result implies that dustbathing in a preferred litter material is a behavioural priority.

That birds may be motivated to get access to litter for different behaviours may also be part of the explanation for the contradictory results for some of the birds in the study of Widowski and Duncan (2000). Although most birds worked harder to get access to litter when deprived, they found that some birds pushed open heavier doors to get access to litter when not deprived, i.e. appeared to be more motivated, when they were not deprived of litter, which is opposite to what would have been predicted. Variation between birds in frequency of dustbathing has been demonstrated elsewhere (Wall, 2003). In the discussion of their results, Widowski and Duncan (2000) criticise the earlier 'behavioural needs' model of dustbathing proposed by Hogan and van Boxel (1993), which proposed a combination of internal motivation and circadian rhythm, and instead propose an 'opportunity' model of dustbathing. The Widowski and Duncan model predicts that given the opportunity, birds will dustbathe and feel pleasure from the performance of the behaviour, but in the absence of external stimuli dustbathing motivation is low. Such discussion can

not however distract from the fact that when presented with a strong external stimuli, such as refreshed litter, a bird will dustbathe even if it has just recently dustbathed (Olsson et al., 2002a) whereas after long deprivation the internal motivation seems to dominate and birds will sham dustbathe even on a bare floor (Olsson et al., 2002a). It therefore seems that there is probably a combination of internal and external influences on this behaviour as well as a gradation from 'full' dustbathing in litter to 'sham' dustbathing in the absence of litter, depending on the motivation of the bird and the circumstances. Recent research has demonstrated that dustbathing behaviour is not as well understood as was perhaps thought at the time that the previous report was written and there is a clear need for more fundamental work in this area.

The 1996 report goes on further to say, "When litter is provided it should be maintained in a friable condition". A suitable substrate is a strong external stimulus initiating dustbathing and it has long been known that some litter materials are preferred over others. For example, substrates with a fine structure, such as sand or peat, are preferred over those with larger particles, such as straw and wood shavings (Petherick and Duncan, 1989; Gunnarsson et al., 2000a; Sheilds et al., 2004) although there does not seem to be a preference between substrates with similar particle size (Duncan et al., 1998). Furthermore, exposure to litter at around 60 days of age was found to be a factor determining whether or not birds would dustbathe in the substrate with which they had previous experience (Nicol et al., 2000) implying that how the birds are reared may be of consequence.

Two other aspects of the environment that have been suggested to influence dustbathing are temperature and the social environment. Duncan et al. (1998) confirmed that radiant heat or a combination of heat and light results in more dustbathing, although in these studies the interpretation may also be that dustbathing is inhibited at low temperatures. However, even if birds are often seen dustbathing together, and it has long been assumed that dustbathing is socially facilitated, recent research suggests that this may not be the case (Lundberg and Keeling, 2003; Olsson et al., 2002b).

Petherick and Rushen (1997) suggest that restricting behaviour will affect welfare if the motivation arises mainly from internal factors, if motivation remains when the behaviour can not be performed or if the motivation is reduced by performing the behaviour rather than achieving the consequences. Furthermore, it has been shown that hens are frustrated when they are prevented from dustbathing (Zimmerman et al., 2003) and that moving birds used to being on sand to wire floor is stressful (Vestergaard et al., 1997) although there may be many other factors in addition to not being able to dustbathe that could contribute to the increased levels of cortisol in this study.

### **7.3.2. Preening, wing flapping and stretching**

Preening, wing flapping and (wing/leg) stretching are self-directed activities that probably play a role in body maintenance, although they may occur in frustrating situations or in a social context. These activities have received relatively little attention in welfare research. This may be because each individual activity is relatively rare within the laying hen's time budget, which can make them difficult to

sample efficiently and reliably. Nevertheless performance of these infrequent activities, albeit at a low frequency, may still be important (Nicol, 1987; Dawkins, 1990). Prevention can, therefore, just as readily lead to deprivation or frustration as more common activities or lead to undesirable physical consequences related to body and feather condition (Appleby and Hughes, 1991; Baxter, 1994).

As it is generally accepted that restriction of movement is an important cause of bone fragility in egg laying hens, the prevention of wing flapping and stretching may also contribute to this problem.

There have been no systematic studies carried out to establish the priority of preening, wing flapping and stretching and the exact social and/or environmental requirements to satisfy this behaviour have not been established.

Investigation of the relevance of self-directed activities and body movements are difficult to achieve using conventional approaches that measure the work undertaken for access to resources because they do not require resources. These may, however, be investigated using other means of imposing environmental costs such as restricted time budgets (Bubier, 1996) or manipulating available space (Keeling, 1994). Preening is generally suppressed when hens have less time (Bubier, 1996) but, unlike many other activities, persists in hens with less usable space (Keeling, 1994). The latter finding may be due to the lower space required to perform preening compared with other activities such as dust bathing or foraging (Dawkins and Hardie, 1989), where social competition may also artificially suppress activities requiring space or movement. Other studies of space requirements have found that comfort activities are suppressed at high stocking densities and that given the opportunity (e.g. when moved to larger enclosures) hens show a high expression ('rebound') of these activities. Nicol (1987) moved hens that had been singly housed, with either 847cm<sup>2</sup> or 2310cm<sup>2</sup> ground areas available, to a 2310 cm<sup>2</sup> area enclosure. Hens housed with less space showed an apparent 'rebound' in comfort behaviours like wing flapping and -stretching on transfer to the larger enclosure. Leg stretching, wing stretching, and feather raising behaviours were also performed more frequently among the hens released from small cages than in birds kept in large cages (Baxter, 1994).

Using different techniques and birds of different weights, Bogner et al. (1979) and Dawkins and Hardie (1989) measured the area covered by hens when performing different behaviours. In the first study white and brown leghorns were used with an average weight of 1.8 kg. In the second study Ross Brown hens with an average weight of 2.02 kg were used.

Their measures ranged between 506 and 1270cm<sup>2</sup> for preening, between 538 and 1118cm<sup>2</sup> for wing stretching and between 860 and 1980cm<sup>2</sup> for wing flapping (the latter are only data from Dawkins and Hardie, 1989).

#### **7.4. Resting and perching**

Hens have a strong preference to perch especially at night. If perches are provided they are generally well used and contribute to bone strength. Stronger bones decrease the risk of bone breakage, particularly when birds are taken out of the house and transported.

Perches can be very attractive at least for some strains, but there is no evidence of disturbance, when no perches are available.

Since the 1996 report further results concerning perches and perching in different housing systems have been published and it is the aim of this chapter to examine these conclusions to see whether they should be revised.

## Rest

No new research concerning rest as a physiological state of the bird and with relevance to housing systems has been published recently. However, there is no doubt about the importance of undisturbed rest.

## Perching motivation

Despite domestication and protection from non-human predators, changes in the use of perches by young domestic fowl with increasing group size were consistent with the antipredator hypothesis (Newberry et al, 2001). This is good evidence for the importance of perching even during daylight. Free ranging hens without a roosting site and hens denied access to a perch showed signs of agitation and increased locomotive behaviour particularly around dusk (Olsson and Keeling, 2000).

Olsson et al. (2002b) found that hens would undertake higher workloads to access a perch that they could use at night than they would pay for “sham” perches that did not allow perching. Oester (2004) reported from investigations in Pennsylvania-Systems with wooden perches on the wire mesh floor where birds were repeatedly observed during dusk. The importance of elevated perches is emphasised by results showing a high number of hens movements trying to perch in Pennsylvania systems with and without elevated perches (about 45 and 80 cm above the floor) during dusk (280.5 intentions per hour compared to 34.5 intentions per hour; in 2752 birds; Fröhlich, 1993).

## Perch qualities

Hens will use the highest accessible horizontal surface for perching at night. This makes the placing of other resources that might be used as a roost such as nest boxes or dust baths important and sometimes difficult to position so as to avoid fouling or competition (Appleby et al., 1993). It is difficult to determine whether perches fixed directly over and onto a wire floor are perceived as perches by the laying hens. Eggs may be laid from these types of perches and observations have revealed frequent attempts to perch somewhere higher (Fröhlich, 1993). Scott et al (1997) referred to the importance of the positioning of perches in an NC system. The angle between perches at different heights should be no more than 45 degrees to avoid frustration and possible landing accidents. As suggested by Lambe and Scott (1998) design and material may be of less importance for the acceptance of a perch by the birds but this may not be true regarding health aspects. Perches should be

positioned as far away from the ground floor as possible, so that other birds are not able to peck birds on them. Perches should also provide sufficient free space for perched birds to stand normally.

## Health

Perches encourage additional exercise, which can increase bone strength and enable hens to roost at night (Appleby and Hughes, 1991). The material, shape and hygiene of perches, and the genotype of the hens are factors in the development of bumble foot (Wang et al, 1998; Oester, 1994), while keel bone deformation is mainly affected by perch design (Tauson and Abrahamsson, 1994).

## Rearing system

The availability of perches from a young age and the possibility of learning to perch during rearing are important for different reasons. As Gunnarsson et al (2000b) stated, rearing without early access to perches seems to impair the cognitive spatial skills of the domestic hen and the effect is both pronounced and long lasting. One of the problems arising from this deficiency may be a higher number of mis-laid eggs. In an other study Gunnarsson et al (1999) showed that rearing young chicks without access to perches and giving them access only after 4 weeks of age doubled the prevalence of cloacal cannibalism in the adult flocks.

Huber-Eicher and Audigé (1999) concluded from epidemiological research in Switzerland that in order to reduce feather pecking chicks should be reared at a maximum density of 10 birds/m<sup>2</sup> and with access to elevated perches. In an other ongoing large scale field investigation Tauson et al. (2004) showed no increase in mortality or signs of feather pecking when comparing rearing of white pullets at 10 and 15 birds/m<sup>2</sup> floor space during rearing to 16 weeks of age. Yngvesson et al., (2004) showed that rearing without perches impaired laying hen escape behaviour in a simulated cannibalistic attack. It may therefore be necessary and helpful to provide feed and water during rearing in such a position as to promote the use of the perches.

## Laying system

During daylight hours, hens in cages furnished only with perches spent approximately 25% of their time on the perch (Appleby et al., 1993). In an aviary the corresponding value was 47% (Carmichael et al., 1999). In cage reared birds Tauson et al (2002) reported 75% - 90% of the birds on the perches in FCs during night. Sewerin (2002) reported 20-24 % of the birds in the light period, 65-75% of the birds in the night time, probably due to the design and arrangement of the perches in the Aviplus cage. At night between 90 and 100% of time is spent on perches (Appleby et al., 1993; Olsson and Keeling, 2000) so long as there is sufficient space for all hens. Wechsler and Huber-Eicher (1998) concluded from their experiments that hens should be provided with foraging material and high perches during the laying period to reduce feather pecking and feather damage. In FCs 14 cm of accessible perch per hen for medium weight hybrids should be adequate (Appleby, 1995) and 12 cm for white hybrids (Tauson, 1984). Tauson et al. (2003) and Wall et al. (2004a) did not

find usage of perches in FCs increased when going up from 12 to 15 cm/bird in either brown or white hybrids probably mainly due to the fact that this increase implied the creation of crossed perches where birds could not perch and which could create a poorer hygiene of the floor. However, it has also been illustrated on video recordings that both white and brown modern commercially used hybrids may all perch together at 12cm free (i.e. not crossed) perch length per bird (Tauson, 2000).

## **7.5. Space and social behaviour**

Sufficient space should be provided to enable hens to perform priority behaviours. The birds' perception of sufficient space is critical and may exceed the physical space required to execute a movement. Evidence that birds will perform high priority behaviours at given space allowances is needed. There must also be sufficient space to permit access to resources e.g. through passageways, entrances to nest boxes or pop-holes, and to permit avoidance of other birds. The impact of spatial allowance on the risk of problem behaviours such as feather pecking, cannibalism and aggression must also be considered.

Social conditions should be such that birds are not subjected to social stress and not prevented by social factors from accessing important resources. In addition, any strong social preferences (e.g. for a particular group size or configuration) should be accommodated. The impact of social conditions on the risk of problem behaviours such as feather pecking, cannibalism and aggression must also be considered.

### **7.5.1. Space requirements**

#### **7.5.1.1. Cage Systems**

Earlier work showing that birds need more space than 450 cm<sup>2</sup> per bird has not been superseded. Birds housed at 600cm<sup>2</sup> per bird, or above, have a broader and more varied behavioural repertoire and greater freedom of movement (Appleby et al., 2002). Some activities require more than 600cm<sup>2</sup>, if only for a certain proportion of time. This has led to a re-interpretation of some early preference test results where hens selected increased cage sizes for a proportion of the day (Lagadic and Faure, 1990). Rather than indicating a preference for a small cage (as stated in the previous SVC report, EC 1996), these results suggest there is an intermittent preference for a large cage that is context dependant (Cooper and Albentosa 2003).

Recent assessments of spatial preference have demonstrated that, unlike hens in NC systems, hens in FCs adopt an even spatial distribution, demonstrated most clearly when hens are allowed to move between two linked FCs (Cooper and Albentosa, 2004; Wall et al., 2002; Wall et al., 2004a). These preference test results suggest that hens in FCs at 600cm<sup>2</sup> cage floor area per bird are still attempting to maximise their personal space allowance. This preference outweighs any competing preference for additional cage height (Cooper and Albentosa, 2004). In commercially available FCs, (Elson, 2004) increasing minimum cage height from 38 cm to 45 cm had no effect on fearfulness or bird position within the cage, and only a minimal effect on behaviour in the usable area (only yawning increased slightly). These results suggest increased area has more value to birds than increased cage height.

Concerns raised in the previous report, that aggression may increase with increasing area allowance per bird, have proved unfounded. Aggression in small groups in FCs is infrequent, and does not appear to pose a welfare problem. Even when space allowances are increased above 600cm<sup>2</sup> per bird, aggression levels remain low (Appleby et al., 2002).

Feather pecking damage is relatively infrequent and does not appear to pose a problem for beak-trimmed hens.

#### 7.5.1.2. Non Cage Systems

In non cage (NC) systems, birds housed at 12 birds per m<sup>2</sup> have an average spatial provision of 830cm<sup>2</sup> per bird. Although this is not much more than in cages, usable space is increased as a result of increased use of vertical space and furniture (Cooper and Albentosa, 2003). An understanding of how birds adapt to the space and social conditions of large flocks is gradually emerging. In larger groups spacing behaviour varies according to activity, time of day and other factors, and space is not evenly used (Carmichael et al., 1999; Appleby, 2004). Social factors such as gregariousness, affiliation, social facilitation, and environmental factors such as the provision of discrete limited resources tend to reduce inter-bird distance and produce clumped distributions (Cooper and Albentosa, 2004). Clumped distributions also arise if sub-populations of birds attempt to avoid aggression or threats, or if birds are fearful. Small flocks of unfamiliar birds adopt more uneven distributions than familiar birds (Lindberg and Nicol, 1996b). In larger flocks, all birds may be unfamiliar, further contributing to uneven distribution. Channing et al (2001) kept birds in multi-level perchery pens in group sizes ranging from 323 to 912 birds. Each pen was designed to house birds at a constant stocking density of 18 to 18.5 birds/m<sup>2</sup>. However, the birds distributed themselves non-randomly so that within representative observation areas, actual stocking density varied from 9 to 41 birds per m<sup>2</sup>. Uneven bird distribution gives increased freedom of movement for some birds and decreased freedom for others (Appleby, 2004). The potential for local overcrowding, even smothering, may increase with group size. The tendency of birds to adopt uneven distributions in large flocks also makes it difficult to prescribe precise space allowances.

Recent studies have highlighted the fact that sometimes individual birds adopt differential patterns of movement within large houses. Carmichael et al (1999) found that two thirds of marked individuals used 80% of space available to them over the course of a year, and Michel and Huonnic (2003) found that the 93% of sampled birds were observed on 3 or 4 of the four vertical levels of aviaries. However, other observational and transponder studies have shown that some birds move relatively freely throughout the flock but others restrict themselves to particular areas (Freire et al., 2003; Oden et al., 2000). Birds in flocks of about 500, marked while roosting at ends of pens, were observed in the same area during the day and returned to same sites at night (Oden et al., 2000). This was not the case for birds found roosting in the middle of a pen, which moved randomly during the day. Differentiated movement patterns will increase variability in individual bird welfare in large flocks. Freire et al. (2003) observed sub-populations of birds with relatively poor plumage and low bodyweight, whose movements were restricted to sub-optimal parts of a perchery

system. The existence of a small proportion of birds, with very poor welfare, is an issue of great concern.

In conclusion, the increased areas per bird in FCs that have been reported here have been beneficial in allowing greater behavioural freedom without serious adverse damaging effects. There is no evidence that the increased FC height required by the EU-Directive has similar beneficial effects.

It is difficult to prescribe precise space allowances in NC systems due to the complexity of the environment and the ways birds distribute themselves.

## **7.5.2. Social requirements**

### **7.5.2.1. Group Size Preference**

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

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

### **7.5.2.2. Familiarity Preference**

Hens can discriminate between familiar and unfamiliar birds, and can discriminate between particular familiar individuals at close range (Bradshaw, 1991; Dawkins, 1995; 1996; D'Eath and Dawkins, 1996). For birds that have formed a social hierarchy, there is strong evidence that they prefer familiar to unfamiliar individuals (Keeling and Duncan, 1989; Bradshaw, 1992; Dawkins, 1996) and that unfamiliar birds are aversive (Grigor et al; 1995; Freire et al 1997). Environmental conditions are likely to influence recognition and discrimination abilities of hens. The ability of domestic fowl to recognise and discriminate objects depends on their achromatic and chromatic perception (Osario et al., 1999) which is likely to be strongly influenced by the prevailing artificial light source provided (Prescott et al., 2003).

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

### **7.5.2.3. Social Strategy**

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

social stability (Lindberg and Nicol 1996b). Tauson and Holm (2001) showed that pecking wounds on the comb at two ages were much more common in groups of 900 white layers in a single level NC system than in 8-hen FCs.

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

In larger group sizes of many hundreds or thousands, birds might be able to form a hierarchy based not on individual recognition, but on some generic status signal, such as bodyweight or comb size (Pagel and Dawkins, 1997). Though there is evidence that such signals are used in experimental flocks (Dawkins, 1995; D'eath and Keeling, 2003; Cloutier et al., 1996) the extent to which they play a role in social behaviour in commercial conditions, where single genotype birds of the same age are physically very similar, is unknown (Cooper and Albentosa, 2004).

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

#### **7.6. Avoidance of Fear and Frustration**

Where possible, domestic fowl will avoid or move away from situations that result in fear. The strength of motivation to avoid a situation (i.e. its overall aversiveness) can be assessed. Methods of quantifying the aversiveness of different situations such as those encountered during handling and transport have been developed (Abeyesinghe et al., 2001 a,b). In situations where birds are fearful, the behavioural priority to move away from the perceived threat, may override all other considerations. This can result in episodes of flock panic or 'hysteria'.

A state of frustration may arise when a bird can perceive but not access a resource. Rather than leaving the source of frustration, birds may persist in attempts to gain access. Continued thwarting can be associated with increased arousal, aggression, vocalisation and pecking behaviour, and an increased risk of feather pecking (Rodenburg and Koene, 2004)

## 8. THE ABILITY OF SYSTEMS TO SATISFY BEHAVIOURAL PRIORITIES

### 8.1. Egg laying

The unanimous results showing the importance of a nest box for laying hen welfare make it clear that the welfare of laying hens is improved if they have access to nests compared with when they do not. Given the above and the small percentage of eggs not laid in nest boxes under commercial conditions, then a first impression might be that the majority of birds have their behavioural priorities associated with egg laying satisfied and only a few do not. However, laying an egg in a nest only tells us that the nest was preferred (relatively) to the floor, not necessarily that it was a good place to lay an egg. Likewise, a large number of eggs laid outside the nest do not necessarily mean that birds' egg laying behavioural needs were not satisfied.

Systematically varying one feature and recording nesting may help identify a threshold for when a nest box becomes less (or more) attractive. The limited research in this area allows the tentative suggestion that the quality of the nest may be important, whereas the size may not. Wall et al. (2002) showed that decreasing the size of the Astro-turf in the nest box to 50 or 30% led to significantly fewer eggs being laid there. However, Guesdon et al. (submitted 2004) only found a reduction in the number of bird movements if the shortest side of the nest was less than 30cm in length. That nest box size may not be a constraining factor is supported by the fact that several birds are often observed simultaneously in the same nest (Wall, 2003). Also, Abrahamsson and Tauson (1997) found no difference in the proportion of eggs laid in the nest when it was shared between 5, 6, 7 or 8 birds. Thus circumstantial evidence seems to suggest that the types of nests used in many systems probably satisfy the behavioural priorities of birds, although this is not the case in all systems (Guesdon and Faure, 2004).

In CCs eggs are laid on the wire floor and in FCs eggs, whether they are laid in the nest box or outside it on the wire, roll out of the cage and are collected automatically. However in all other systems, eggs laid outside the nest boxes have to be collected manually. This is time consuming and, depending on where the egg is laid, it may become cracked or dirty. In these systems then, providing a nest site that all birds find attractive is cost effective.

The work of Freire et al. (1996) showed that birds were motivated to get access to an enclosed nest site and that a semi-enclosed nest site (with wire walls) did not decrease motivation to work to get access to an alternative pen to the same extent. This result would suggest that any housing system should ideally provide a discrete enclosed nest site. The EU-Directive requires a separate nest site to be present in enriched cages, but it does not specify that it should be enclosed.

Providing nests that satisfy hens is only part of designing a housing system that satisfies the complete egg laying behaviour of birds. Birds should be able to get access to the nests. Aggression around nest boxes has been shown to be higher than in other places within a system (Oden et al., 2002), which may imply that despite our knowledge of nest design, in some systems at least, nests may not be

positioned optimally in the building or that there are not always enough nests available, thus creating competition or frustration. Since not all nests are equally used by birds, this may occur even if the total numbers of nests is adequate. Furthermore, it has been clearly demonstrated that birds reared without perches are less able to find, and so use, raised nest boxes (Appleby et al., 1988) and confirmed in epidemiological studies on commercial farms (Gunnarsson et al., 1999). The distance and angle birds have to jump to nests also significantly affects access (Lambe and Scott, 1998) with downward jumps being more difficult for birds than jumps angled upwards (Moinard et al., 2004).

## **8.2. Drinking, feeding and foraging**

Behavioural priorities concerning drinking and feeding are satisfied in all housing systems because they are essential for production and feed and water are provided ad libitum. It may be important to prepare the birds during the rearing period to give them experience of the drinking system they will encounter during the laying period.

Foraging is a behaviour pattern with a high priority. It needs enough space for walking and scratching, friable litter which can be manipulated by the birds which is always available in the rearing and laying systems.

CCs are not able to satisfy these requirements, unless deep feed is provided in the troughs and is regarded as providing feed and foraging material and the cages provide plenty of space. FCs, especially the larger group size ones which have more space, meet the requirements but only if it is possible to offer an adequate amount of real litter every day during the light phase. In NC systems the litter area has to be available to the birds during light phase all day. Thus all NC systems should fully meet the foraging requirements.

## **8.3. Comfort behaviours**

### **8.3.1. Dustbathing**

In loose housing systems where there is litter on at least one third of the floor, there is no evidence of birds showing sham dustbathing, that is to say, performing dustbathing on the wire or slatted parts of the system. The type of litter material used in the different countries varies and even if a slightly less attractive material is used, such as wood shavings, this is usually soon broken down into smaller particles that when mixed with faeces etc. at least visually resembles peat, which is the preferred litter in experimental studies. Oden et al., (2002) reported significantly fewer birds dustbathing when the quality of the litter was poor compared to when it was good. Nevertheless, assuming that the litter is dry and friable, it can probably be concluded that the litter material is appropriate to satisfy the dustbathing priorities of the birds.

Besides appropriate litter material, another important criterion if a system is to satisfy the behavioural priorities of the birds is that there is sufficient space to dustbathe. Recent work on dustbathing in loose systems confirms earlier work showing that the density of birds on the litter at peak dustbathing times is very high (Oden et al., 2002). When the distribution of aggression within a system is compared, then it was

highest around the nests and on the litter (Oden et al., 2002). Nevertheless, it may be possible to conclude that loose housing systems with good quality litter over a large enough area of the floor are able to satisfy the behavioural priority of birds for dustbathing.

The picture is less clear in FCs. Wall (2003) showed that over a whole production cycle the average hen visited a large litter box located on top of the nest between 25% and 68% of the days, which would be in keeping with the fact that birds tend to dustbathe once every second or third day but also indicated a possible difference among individuals in motivation to use litter per se. On the other hand, Lindberg and Nicol (1997) found that about two thirds of dustbathing bouts were on the cage floor in FCs, even when there was free access to the dustbath and that this figure increased to 92% sham dustbathing when access to the dustbath was restricted to the afternoon. Olsson and Keeling (2003) found similar results with a high frequency of sham dustbathing. Olsson and Keeling (2003) also specifically investigated whether this high frequency of sham dustbathing could be a result of competition for the dustbath at peak dustbathing times, but found the occurrence of sham dustbathing rarely coincided with the dustbath being occupied.

There are several possible interpretations for these findings. The most straightforward is that the dustbaths in the cages used by Lindberg and Nicol (1997) and Olsson and Keeling (2003) were too small, even if they were commercially available designs. There is also the possibility that the location of the dust bath was not found ideal by the birds. Guesdon et al. (submitted 2004) found significant effects on dustbathing behaviour according to the size of the dustbath. They found differences in almost all behaviour patterns measured, for example a lower frequency of wing shaking and dust tossing and longer latencies to start dustbathing in smaller dustbaths and even proposed that the size of their largest dustbath, which was 40x45cm might be insufficient. If correct, this would make it very important to distinguish between the large FCs, which have only recently come into more general use, and the widely used small FCs.

An alternative explanation for the frequent sham dustbathing in FCs, proposed by Olsson and Keeling (2003), is that since birds to be housed in FCs are often reared in cages which do not have litter, the birds do not develop normal dustbathing behaviour, which is dependent on experience (Johnsen et al., 1998). Whether or not sham dustbathing is satisfactory from an animal welfare point of view for birds that have not developed the normal dustbathing behaviour is a further complication to the discussion on sham dustbathing in general. It does, however, raise the question of how birds to be housed in FCs as adults should be housed during rearing and whether or not that rearing system should contain litter.

### **8.3.2. Preening, wingflapping and stretching**

To our knowledge, there are no clear empirical studies available comparing the possibilities for preening, wing flapping and stretching in different housing systems. Clearly, because of spatial restrictions, wing flapping will be prevented in conventional cages and may be hampered in the smaller types of furnished cages.

This may be the background of brittle wing bones in birds housed in CCs. Most NC systems do not seem to pose any physical restriction to these comfort behaviours. However, disturbance of behavioural patterns by, for instance, social interactions can not be completely ruled out.

#### **8.4. Resting and perching**

In all the systems where the dark phase lasts for several hours birds will sleep. From a biological point of view it is understandable that hens use perches for resting during the night.

Perching is not possible in CCs, unless perches are added. Birds do perch well in FCs and NC systems to a considerable extent, but it is not known whether the perch design, location or degree of elevation fully satisfies their perching motivation. Lambe and Scott (1998) found that layers do not have high preferences for perch materials or shapes. Many observations suggest that perch location, position and design are important in FCs and NC systems.

#### **8.5. Space and social behaviour**

Three spatial and social components affect bird behaviour and welfare in any system: the number of individuals in a group, the total area and the area per individual. Although fixing any two also fixes the third, they may all have separate effects (Appleby, 2004). The EU-Directive sets limits on area per individual but provides no guidance on how group size and area should be manipulated to achieve these limits.

##### **8.5.1. Cage Systems**

Recent work in the USA confirms earlier European studies showing considerable benefits of increasing space allowances for laying hens in CCs (Anderson et al., 2004). In this study, birds housed with more space moved more freely, and aggression did not increase and cause poor welfare. A recent theoretical analysis of freedom of movement in laying hens suggests that the EU-Directive requirement of 750cm<sup>2</sup> per bird, with 600cm<sup>2</sup> of 45cm high in FCs, gives a substantial increase in freedom of movement compared with the previous 450cm<sup>2</sup> per bird minimum in CCs (Appleby, 2004). In a recent commercial scale trial of furnished cages in the UK (Elson, 2004) increasing space allowances over a range from approximately 600cm<sup>2</sup> per bird to approximately 870cm<sup>2</sup> per bird, was associated with significantly improved plumage condition. Further analysis is currently being conducted to examine the effects of increased space allowance on behaviour. Space allowances of over 800cm<sup>2</sup> per bird in FCs were also associated with significantly reduced mortality due to thermal stress compared with birds housed in conventional cages at 635-660cm<sup>2</sup> per bird, possibly due to improved heat dissipation (Guesdon and Faure, 2004) albeit within an inadequately controlled environment.

##### **8.5.1.1. Space and social influences on the expression of behavioural priorities in FC's**

Birds do not just need to move, but need to perform a variety of specific behaviours, including comfort activities such as wing stretching and preening. Recent studies have demonstrated the benefits of increasing space allowance in cages, and the synergistic benefits of increasing space allowance in FCs in terms of increased behavioural repertoire and freedom of movement (Appleby et al., 2002). Behaviours such as dust-bathing are increased as group size decreases from 8 to 5 birds per cage at 600cm<sup>2</sup> per bird (Abrahamsson and Tauson, 1997) in FCs. Within FCs, increased spatial allowance, from 750cm<sup>2</sup> to 3000cm<sup>2</sup> per bird, allows increased performance of comfort activities such as tail-wagging and wing/leg stretching, and also increased locomotion (Albentosa and Cooper, 2004).

However, certain behaviours, notably wing flapping and flying, are rarely or never observed in cages, even at low stocking densities (Freire et al., 1999; Appleby et al., 2002; Albentosa and Cooper, 2004). There is some evidence from rebound studies to suggest that these behaviours are important (Nicol, 1987) but it seems that they are prevented by spatial restriction, even at allowances that exceed the current recommendation (Cooper and Albentosa, 2003).

The evidence suggests that space allowances of 750cm<sup>2</sup> per bird have resulted in significant improvements in hen welfare, compared with the previous situation when birds were housed at 450cm<sup>2</sup> per bird. However, even at these allowances, space is at a premium and some behaviours are prevented due to insufficient space. Based on a theoretical analysis of freedom of movement, Appleby (2004) proposes space allowances that are higher than those required in the Directive 1999/74 for FCs and which depend on group size. This is difficult to confirm in the absence of detailed studies examining bird preferences for spatial allowances and how these preferences vary with genotype. Information about how birds actually share space within groups of different sizes is also needed.

Group size may affect the expression of high priority behaviour independently of spatial allowance, if factors such as social facilitation or competition are important. Abrahamsson and Tauson (1997) examined group sizes ranging from 5 to 8 in FCs for birds kept at a constant stocking density of 600 cm<sup>2</sup> per hen nest and litter box excluded. There were no effects of group size on measures of resource use such as the % of eggs laid in the nest or the % of hens roosting on perches. However, the smaller group size was associated with increased use of the sandbath for dustbathing. This suggests that some birds in the larger groups had difficulty accessing that resource.

#### **8.5.1.2. Space and social influences on feather pecking, cannibalism and aggression in furnished cages**

In general, levels of performance of these damaging behaviour in trials of FCs have been low (Appleby et al., 2002; Tauson and Holm, 2002; Wall et al., 2004a).

Increasing space allowance does not generally seem to increase the risk of feather pecking or aggression in FCs (Appleby et al., 2002). Increasing group sizes within the range of 5-8 birds per group was not associated with an increase in feather pecking, assessed by plumage condition and mortality in one study, (Abrahamsson

and Tauson, 1997). But mortality was significantly higher with 8 birds per cage than 4 or 5 birds per cage in the Year 2 study of Appleby et al. (2002). In this same study, aggressive pecking (but not feather pecking or cannibalism) was slightly higher in the groups of 8 birds per cage, although this was not thought to be responsible for the increased mortality.

In contrast, the original studies of colony-type cages that housed birds in groups of approximately 25 or 100, reported high prevalence of this injurious behaviour (Wegner, 1990). When birds were housed in floor pens feather pecking increased with group size over this range (Bilcik and Keeling, 2000). Studies in larger groups in the Netherlands within FCs indicate that mortality due to cannibalism in non-beak trimmed birds varied largely and in some studies reached levels of about 45% (Van Emous et al., 2003). Early indications in the UK with beak trimmed birds are that similar problems are not observed in FCs, even with group sizes falling within this range. This seems to suggest that large colony FCs may be more difficult to manage with non-beak trimmed birds.

## **8.5.2. Non cage systems**

### **8.5.2.1. Space and social influences on the expression of behavioural priorities in non cage systems**

NC systems provide sufficient space for many birds to perform high priority behaviours such as nesting, dustbathing and all types of movement. However, spatial allowance and flock size may influence the extent to which birds are able to access resources. For example, Carmichael et al (1999) housed birds in an experimental perchery at a constant flock size of 300 birds, with stocking densities ranging from 10 to 19 birds/m<sup>2</sup>. Increased density was associated with a reduced proportion of birds on litter areas, reduced bird movement, foraging and dustbathing. It is unlikely that difficulties in accessing resources will be borne equally. Evidence suggests that some birds may fare particularly badly (Freire et al., 2003).

### **8.5.2.2. Space and social influences on feather pecking and cannibalism in non cage systems**

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

Gunnarsson et al. (1999) also found no increased risk of feather pecking and cannibalism associated with stocking density ranging from 9 to 20 hens/m<sup>2</sup>. Green et al. (2000) and Pöttsch et al. (2001) reported no strong association of stocking density with feather pecking or vent pecking, although in free-range flocks, increased use of the range (which would have lowered stocking density in the house) was strongly associated with a reduced risk of these behaviours. However, Huber-Eicher and Audigé (1999) found that high stocking density was a risk for feather pecking in Swiss flocks.

Replicated experimental studies are few, but also present inconsistent evidence about the effect of stocking density on feather pecking and cannibalism. Thus, Carmichael et al (1999) found no effect of stocking density (ranging from 10 to 18 birds/m<sup>2</sup>) on feather pecking and cannibalism in birds housed in an experimental perchery in flock sizes of 300. However, Nicol et al (1999) reported that increased stocking density (ranging from 6 to 30 birds/m<sup>2</sup>, and accompanied by increased flock size) was associated with increased mild and severe feather pecking and poorer plumage condition.

Replicated experimental studies examining commercial flocks are even scarcer. However, a UK study of beak-trimmed commercial flocks (Zimmerman, 2005), housed at stocking densities of 7 to 12 birds/m<sup>2</sup> (with some control for flock size, which varied from 2450 to 4200) has just been completed. In this trial, feather pecking was most prevalent in the birds housed at the lowest stocking density of 7 birds/m<sup>2</sup>. For birds that were housed at 12 birds/m<sup>2</sup>, feather pecking was significantly lowered by a modified management regime based on previous epidemiological findings (i.e. the use of nipple drinkers rather than bell drinkers, no lights in nest boxes, onset of lay delayed by 1 week, improved litter management strategy).

### **8.5.3. Space and social influences on aggression in non cage systems**

The social strategies adopted by hens in large flocks means that aggression is not generally a problem. Hens raised in larger flocks are less aggressive (D'Eath and Keeling, 2003). Birds kept as adults in large flocks have also shown lower levels of aggression in recent studies compared to birds housed in small to medium sized flocks. In general aggression in these large flocks is infrequent, averaging less than one aggressive interaction per bird per hour (Carmichael et al., 1999; Hughes et al., 1997; Nicol et al., 1999), except in the smallest flocks of 72 birds where aggression averaged 1.65 interactions per bird per hour (Nicol et al., 1999). No effects of group size, varying from 250 to 5000 on aggression was reported (Oden et al., 2002). However, even low levels of aggression could be reduced further by housing male birds within flocks of about 500 hens (Oden et al., 1999).

### **8.6. Housing System Influences on Fear, Deprivation and Frustration**

The more frequent and varied stimulation normally experienced within the home environment might explain why lower levels of fearfulness are found in layers housed in floor pens rather than in CCs, in the lower rather than the top tiers of multi-tier CCs, and aviaries rather than CCs (see reviews by Jones, 1996; 1997), and also free range rather than CCs (Scott et al., 1998). No results have been found showing where FCs could be placed in this scale of fearfulness. The additional of long-cut straw to pens reduced fearfulness assessed by tonic immobility duration (El Lethey et al. 2000).

At the end of the economic laying cycle the birds need to be removed and to be replaced with a new flock of pullets. Regardless of the design of the housing system, the human intervention required at this stage has a huge impact on the birds being handled, and considerable stress and injury can be inflicted at this time. A general

principle employed during catching of all poultry species is to try to reduce bird activity by keeping light levels to a minimum. A single study concluded that where the light intensity at catching was the same as that during lay, regardless of actual intensity, birds were more difficult to catch than when the light intensity was reduced (Gregory et al., 1993). Removal of hens from NC systems requires a different strategy. The freedom of movement in such systems allows a greatly enhanced opportunity for escape behaviour increasing the risk of injury. In general, increased system complexity increases the difficulty of capture. Environmental enrichment during the laying period may help to reduce the fear response elicited by the depopulation procedure itself and hence reduce the likelihood of injury occurring (Reed et al., 1993), although this may be only a marginal effect at this very challenging time. There are no comparative studies evaluating the fearfulness of birds depopulated from different systems.

Signs of deprivation and frustration include specific vocalisations, displacement behaviours and pacing. Sherwin and Nicol (1993b) studied the effect of adding nests to conventional cages in an early prototype design of a FC. They monitored pre-laying behaviour and found that displacement behaviours and pacing less frequent in the cages with nests. Zimmerman et al. (2000) found that frustration vocalisations increased when hens were expecting access to food, water or a dustbath, beyond the level observed during deprivation of these resources. Housing systems that do not provide these resources, or that restrict access for some birds, are likely to be associated with these negative emotional states.

## **9. AREAS OF CONCERN/MANAGEMENT OF PROBLEMS**

### **9.1. Beak treatment**

The beak is an important sensory organ in pullets and laying hens, used for foraging and feeding. It is also a potential weapon that enables hens to inflict feather and flesh pecking, sometimes with severe consequences such as cannibalism, which may involve serious wounds, infections and death. Therefore interventions such as debeaking and beak trimming i.e. partial beak amputation have been used for many years to minimise the beak's possible deleterious effects. Recently other techniques intended to be less painful than the operation of partial beak amputation have been investigated, with the same purpose of reducing the occurrence of pecking damage to feathers and flesh. Glatz (2000) reviewed beak treatment including traditional hot blade, cold blade, arc, robotic, bio, laser and infrared trimming and chemical methods.

#### **9.1.1. Beak trimming**

The term beak trimming is used to refer to the partial amputation of the beak. Beak trimming is common practice in the poultry industry aimed at preventing pecking damage to birds (Craig and Lee, 1990; Kuo et al., 1991). The operation traditionally consisted of the removal of one-third to one-half of the upper mandible and sometimes also about the same proportion of the lower one with a heated blade, which cuts and cauterises the mandible. Routine beak trimming of day old chicks or pullets aged about 1 to 8 weeks old, using mainly the hot blade method, has been

performed in many hatcheries and farms. However, the EU-Directive states “all mutilation shall be prohibited” but that in order to prevent feather pecking and cannibalism, beak trimming may be authorised provided it is carried out by qualified staff on pullets that are less than 10 days old. In some countries, like the UK, not more than one third of the beak may be removed. In other countries, like Norway, Finland and Sweden, beak trimming was banned many years ago and in others it is currently being questioned.

The purpose of beak trimming is to reduce pecking damage to feathers and flesh of hens (Hughes, 1985). This means that in housing systems where the risk of feather pecking and cannibalism is evident the operation may be performed as a preventive measure (Gentle, 1986). Craig and Lee (1990) found that beak trimming was highly beneficial in reducing beak-inflicted feather loss and mortality from cannibalistic pecking in two of three commercial genetic stocks of caged hens. Birds of the third stock suffered no greater feather loss when their beaks were left intact than when they were trimmed, and mortality from cannibalistic pecking was essentially absent in this stock when kept in cages, regardless of beak trimming.

The influence of beak trimming may vary according to management conditions and flock characteristics. In recent French studies in cages it varied from a mild increase in mortality of 1.9% for beak trimmed hens to 2.8% for non-beak trimmed (Michel et Pol, 2001) and to more severe mortality due to cannibalism of 3-5% for beak trimmed hens to 51-52% for those with intact beaks (Guémené et al., 2004). In a recent UK comparison of trimmed (at 8 days old) and intact beak hens, severe cannibalism and mortality were experienced only in those with intact beaks: mortality in these brown hybrids from 16 to 35 weeks of age was 1.9% in beak trimmed hens and 9.9% in those with intact beaks (Elson, 2004). Although in certain genetic stocks the operation may reduce the risk of damaging pecking activities, it can have adverse consequences for the birds. These include a reduction in feeding activity (Gentle et al., 1982; Duncan et al., 1989) leading to a lower bodyweight until the age of 35 weeks (Andrade and Carson, 1975). According to Craig and Lee (1990) body weight gain was initially suppressed following beak trimming but birds were only marginally lighter by 27 weeks of age. Hens may suffer persistent pain following the operation (Breward and Gentle, 1985; Gentle et al., 1990) due to the presence of neuromas. In contrast Gentle et al, (1997) found little evidence of pain and neuroma formation after trimming was performed at a young age of 1 or 10 days old. They investigated subsequent behavioural and anatomical consequences of two beak trimming methods and concluded that mild or moderate beak trimming, where regeneration occurs, exerts its behavioural effects not by altering the length or shape of the beak but by sensory deprivation, by removing the sensory receptors located at the tip of the mandible. These specialised receptors do not regenerate. The authors postulated that for effective trimming only the tip needs to be trimmed. However, since the study finished when the birds were 6 weeks old no information was gathered on the effect during the laying period. It is known from other studies, that the effectiveness of beak trimming in preventing feather damage depends on the proportion of the beak removed (Kuo et al, 1991; Rooijen and van der Haar, 1990).

Van Liere (1995) investigated responses to a novel-preening stimulus after beak trimming in laying hens and concluded that the operation had long lasting

consequences. This finding is in agreement with hens' long-term passivity after beak trimming, as demonstrated by Lee and Craig (1991).

Grigor et al., (1995) concluded that, in the long term, because beak trimming is a traumatic procedure, other methods of reducing damaging pecking should be sought. Many authorities oppose all forms of mutilation and either prohibits beak trimming already or plan to do so if and when an effective more humane beak treatment can be found. Meanwhile, in order to reduce the variation between operators and thus improve beak trimming standards, codes of best practice have been formulated in some countries e.g. Australia (Glatz et al, 2001) and the UK (British Egg Industry Council – BEIC, 2004).

### 9.1.2. Bio, laser and infrared beak treatments

Beak trimming, as described above, has been carried out for over 60 years mainly by cutting the beak with a hot blade; cold cutting has also been tried. More recently bio, laser and infrared amputation methods have been tried.

**Bio treatment.** The Bio-Beaker, developed by Sterwin Laboratories in the USA in 1980, used a high voltage electrical current to burn a small hole in the upper mandible of day old chicks. Its main advantage was that it could be carried out in controlled conditions in the hatchery. The aim was that the young chick would lose the portion of its beak from the hole to the tip by about 14 days of age. Whilst reasonably successful in turkey poults it did not work well with pullet chicks and many of them had to be re-trimmed using the hot blade method. Also, as Grigor et al. reported in 1995, the hole took about 0.25 seconds to burn and during this time, and before it while their beaks were being inserted into the mask of the instrument, the chicks struggled.

Related to the bio-beak process was the method developed for broilers by Smith (1997) who used the hot blade to burn an area near the tip of the upper beak. This procedure allowed a thin base to remain in the beak under the burn. The chick could continue to eat and eventually the end of the upper beak dropped off.

**Laser treatment.** Lasers operate by sending energy to the target tissue; the heat is absorbed and in the process the beam will, if strongly directed, cut the tissue. Many lasers are equipped with cooling systems to decrease the temperature around the treated area, providing a mild anaesthetic effect. A variety of types are now available including contour, ND Yag and coherent CO<sub>2</sub> lasers. Some have specialist surgical applications. The cost of laser technology is declining rapidly.

Rooijen and van der Haar (1997) reported on a laser beam method that cuts the beaks of day old chicks. No details were provided by the authors on the type of laser used or the severity of beak trimming. By sixteen weeks old the beaks of laser trimmed birds resembled those of untrimmed ones, but without the tip. Unfortunately, feather pecking and cannibalism during the laying period were highest among the laser-trimmed hens. These results suggest that the severity of beak trimming by laser was insufficient enabling regrowth of the beaks. However, the authors

commented that it might be expected that the use of laser beak trimming would enable greater uniformity in beak trimming and improve welfare.

In a project designed to develop a welfare friendly laser beak-trimming machine in 2003, Glatz (2004) tried several types of laser including an ophthalmic one. He reported that current results indicate that there is potential to produce an effective and suitable machine which would be economic to use in hatcheries.

Infrared treatment: Over the past 10 years an infrared upper beak shortening treatment has been developed. It was used first on young turkey poults and more recently on day old chicks. Infrared beak treatment is a patented automated process pioneered by Novo-Tech Engineering in America and now used in several countries. A recent large-scale experiment revealed that, because the operation is performed in the hatchery, it can be done for about one third of the cost of hot blade trimming; in other respects the results were similar to those of hot blade trimming (Ruszler, 2004).

Day old chicks are attached by the head/neck to an automated carousel and then subjected to a localised, non-contact, high intensity infrared energy source focussed on the top of the beak near its tip. No surgical intervention is involved and there is therefore no loss of blood. After a short time necrosis takes place at the treatment site in the upper mandible. A few days later the end of beak softens and by two weeks after treatment the end of the beak erodes away. By twelve weeks of age the treated beak is generally similar in shape and size to one trimmed at a few days old by the hot blade method. During this time the chicks are said to feed normally. The treatment is claimed to be very accurate so that the resulting beak shape is very similar in all treated birds. Adjustments to the treatment machine can vary the amount of beak removed.

The manufacturers suggest that treatment, and the subsequent experience of the chicks, is free of pain but this could be questioned as evidence for it is lacking. Studies to compare infrared, hot blade and laser beak treatments for pain responses and neuroma formation are under consideration for 2004/5 (Glatz, 2004)

### **9.1.3. Beak blunting by abrasion**

It is known that birds naturally shorten and blunt their beaks to varying degrees when they have access to abrasive materials. Therefore, in the Netherlands and the UK pilot research has been conducted to blunt the tip of the beak by means of abrasive materials in the feed trough (Fiks-van Niekerk and Elson, 2004). The idea for beak blunting by this means came from claw shortening by abrasion (Tauson, 1986; Elson, 1990), which has been a requirement of the EU- Directive for laying hens in cages since 01/01/03. A variety of abrasive materials have been found to be effective for claw shortening when fitted to the anti-egg eating baffle plates of laying cages (Elson, 2003; Fiks-van Niekerk et al., 2002; van Niekerk and Reuvekamp, 2000a). The idea was that pullets and hens would blunt the tips of their beaks themselves and then continue to keep their beaks blunt. The reason for putting the abrasive in the feed trough is that this is a place where hens spend much time pecking at the feed and the inner surfaces of the feed trough.

In the pilot study in the Netherlands strips of abrasive material were glued onto the inner surfaces of the feed troughs of cages and in a subsequent larger study just to

the base of the troughs, where they seemed most effective. Their effect on hens' beaks was compared to that of plain troughs. In the UK pilot study most of the inner surfaces of feed troughs in floor pens during rearing, and both floor pens and cages during lay, were coated with hardened abrasive paste. The effect of these on beaks was also compared to that of plain troughs.

In each of these studies the beaks of pullets and/or hens were blunted. However, these early results should be treated with caution since in both countries only one hybrid was used, and in the UK the pilot study is not yet completed. The hope is that this mild intervention of allowing birds access to abrasives in their feed troughs will remove the sharp tip of the hook of the upper mandible, and that this will result in less damaging feather and flesh pecking. Whether that aspiration is achieved remains to be seen. In the larger Dutch study, despite the beaks being blunted, no difference in feather cover was observed. However, in this study, the use of the abrasive strip did result in lower mortality caused by pecking.

If beak blunting proves sufficiently effective in small-scale studies further research and development will be required to establish:

1. whether it is possible to apply the abrasive blunting technique practically and economically on a commercial scale and
2. its effectiveness, or otherwise, in minimising feather pecking and cannibalism in several hybrids in a range of housing systems.

#### **9.1.4. Management practices**

Although beak treatment can reduce pecking damage it would be preferable that hens should be housed and managed in such a way that beak trimming was not necessary. If beak trimming were disallowed increases in the prevalence of feather pecking and cannibalism could be expected in some flocks. Practical experience indicates that reducing light intensity can sometimes control this. In the present state of knowledge and experience such a reduction in light intensity would be necessary with most genotypes. However, while this intervention may minimise the occurrence of these behaviours it can also result in poor welfare if normal activities are prevented. It may also increase the incidence of floor eggs. Some degree of light dimming may be preferred to widespread prophylactic beak trimming, but it should be emphasised that it would demand a high standard of management to recognise any pecking damage at an early stage. Good control of light intensity is also likely to be important, to minimise feather and injurious flesh pecking, in combination with any of the above beak interventions.

## **9.2. Feather pecking**

### **Management**

Despite considerable research efforts over many years, an unambiguous prevention strategy for feather pecking remains to be found. The most commonly used remedial measure against damage from feather pecking is treatment of the beak. Since such treatment itself raises welfare concerns, other management strategies are urgently needed.

As reported in the 1996 report, important causal factors include type of floor, stocking density, flock size, food structure and composition, genotype and light intensity (e. g. Allen and Perry, 1975; Blokhuis, 1986; 1989; Blokhuis and van der Haar, 1989; Duncan and Hughes, 1973; Elson, 1990; Kjaer and Vestergaard, 1999; Nicol et al., 1999; Savory et al., 1999; Simonsen et al., 1980).

Blokhuis and Van der Haar (1992) concluded that the most important strategy to prevent feather pecking was to offer an adequate substrate, which should be included during the rearing period also. Nørgaard-Nielsen et al. (1993) investigated the effect of environment during the rearing and laying periods and it was concluded that rearing with access to sand or peat for dust-bathing reduced the later tendency to feather peck.

Given that it has been argued that feather pecking occurs as a result of misdirected pecking, a possible solution would be to increase the likelihood that such pecking was targeted at another object in the environment rather than to the feathers of conspecifics. Environmental enrichment in the laying environment by means of cut straw from a basket had a reducing effect on feather pecking (Nørgaard -Nielsen et al. (1993). Also provision of additional pecking incentives in the litter during rearing seemed effective (Blokhuis and van der Haar, 1992). Other enrichment devices have been tested and shown to contribute to less pecking feather pecking. Thus, the addition of simple string devices to the pens of non-beak-trimmed high-feather-pecking birds decreased feather pecking behaviour, and to the cages of non-beak-trimmed commercial layers significantly improved feather condition (McAdie et al. 2004).

The presence of a hen during rearing of chicks did not reduce feather pecking (Roden and Wechsler, 1998) nor did the presence of males in laying hen flocks (Oden, et al., 1999).

### **9.3. Cannibalism**

Since the previous report, there has been a considerable amount of work in this area. This was reviewed by Savory (1995) and recently in a comprehensive review by Newberry (2004). Studies can be split into those using epidemiological analyses, those involving clinical and/or behavioural observations on commercial farms and experimental studies carried out in laboratories. Unfortunately, though, despite this increased research, cannibalism still remains an unpredictable behaviour occurring in practice in all housing systems. The number of birds that are wounded or die because of cannibalism is usually higher in NC systems than in CCs or FCs and it seems to be more common in certain genotypes. In several countries beak trimming is routinely applied to many young hybrid pullets destined to be housed in NC systems in order to avoid the risk of injurious pecking and cannibalism.

The consequences of an outbreak, in terms of bird mortality, increase with increasing group size, and can be very severe with serious impairment of bird welfare. Such consequences also include infection of wounds and consequent septicaemia and medication as well as the possible need, as a last resort, to beak trim the adult hens, which is a serious insult, or to sacrifice the flock.

One death is often followed by more in the same group (Tablante et al., 2000), which could be a result of the fact that injured, less fit or 'different' individuals are attractive victims (Yngvesson and Keeling, 2001; Cloutier and Newberry, 2002, McAdie and Keeling, 2000; Savory et al., 1999) and/or that birds may learn from one another (Cloutier et al., 2002). Under commercial conditions the two most common methods of controlling cannibalism are beak trimming and dim lighting. However, beak trimming is not a desirable method for other welfare reasons and, although it has been shown previously and confirmed more recently (Kjaer and Vestergaard, 1999) that cannibalism increases with increased light intensity, keeping birds in dim light necessitates increasing the light for inspection, which itself increases cannibalism (Pöttsch et al., 2001) and so may not be a desirable method of control either. In floor systems, a very dim light can also result in an increase in the number of eggs laid outside the nest boxes. In FCs this is not such a problem since birds probably find the nests anyway and, even if they do not, the eggs roll out of the cage and can be collected automatically.

Management aspects that were associated with an increased incidence of vent pecking in hens kept in NC systems, according to the questionnaire study of Pöttsch et al. (2001) included the flock coming into lay before 20 weeks of age, using dim light or any other measure to encourage the use of the nest box, turning the lights up when the flock is inspected, changing the diet during lay and the use of hanging bell drinkers. There were also some risk factors associated with use low use of the outside area in free range systems and diseases such as egg peritonitis and infectious bronchitis. In the epidemiological study by Gunnarsson et al. (1999), which only looked at risk factors associated with how the birds were reared and the prevalence of mortality due to cannibalism during the laying period, the most significant risk factor was whether or not the birds were reared with perches. Some of these associations were very strong e.g. the use of light to encourage the use of nest boxes reported in the Pöttsch et al. (2001) study increased the risk of vent pecking 9.6 times compared to not having light in nest boxes, the use of hanging bell drinkers increased it 5.5 times, whereas the effect of rearing birds with early access to perches reported in the Gunnarsson et al. (1999) study reduced later mortality due to cannibalism by almost a half. These management aspects may help decrease the problem with cannibalism in loose housing systems if applied more widely. It has been shown in a study of organic poultry farms that producers or keepers who have only kept laying hens for a short period i.e. those with probably less experience, have more cannibalism (Koene, 1997) emphasising again the importance of management.

Cannibalism is often triggered by problems with feeding and meeting the nutritional requirements of the birds is obviously important. Deficiencies in sodium (Wahlström et al., 1998a) and low protein diets (Ambrosen and Petersen, 1997) have recently been implicated in outbreaks of cannibalism, although not all studies comparing diets have found differences (Kjaer and Sorensen, 2002; McKeegan et al., 2001) implying that while deficiencies may stimulate outbreaks, manipulations of diets do not prevent them. More important seems to be the way in which the food is presented, in particular that it is time consuming to eat (Hartini et al., 2002). The provision of appropriate litter for foraging, which is clearly implicated in feather pecking, is probably also important for cannibalism. For example the association between hanging bell drinkers and vent pecking in the work by Pöttsch et al. (2001) may

possibly be explained in some cases by poorer litter quality in systems with this type of drinker.

Since cannibalism is most frequent around the start of egg production and up to peak production, it has been suggested to have a hormonal influence. This has been confirmed in epidemiological studies (Pöttsch et al., 2001) and promoting early onset of lay by extra light stimulation has been suggested to lead to an increase in cloacal cannibalism.

Even if management has a strong effect on the incidence of cannibalism, experience in practice suggests there are also differences between strains of birds in their tendency to show this type of behaviour. Craig and Muir, (1996) have shown that it is possible to use group selection methodology to select against beak inflicted injuries within a strain of bird. However, such selection against cannibalism is not easily implemented in commercial lines of birds and means reduced selection pressure on other commercially viable traits. Ultimately, though, genetic selection is probably one of the ways forward to reduce the problem of cannibalism.

In her summary Newberry (2004) recommends that “hens be provided with perches, attractive foraging materials and feed in small particle form such as mash or crumbles throughout rearing as well as in the laying hens. The age at first egg should be delayed until the hens are at least 20 weeks old and the birds should be managed to minimise the availability of preferred victims and to prevent the discovery that flock mates represent a highly palatable foods source. High perches should be available to act as a refuge, nest boxes should be designed to minimise visibility of the cloaca during oviposition and sufficient space should be provided to facilitate access to all resources.” Much of this advice could be better applied in practice than it is today, but the multifactorial nature of the problem probably means that there will always remain a large component of unpredictability in this welfare problem.

#### **9.4. Lighting**

In hot climates a common practice in cage houses is to provide a short period (e.g. 1 hour) of light during the dark period. As it is cooler in this period, birds will be stimulated to eat. This will enable them to get their daily allowance and can also have a beneficial effect on eggshell strength. However, some authorities recommend an uninterrupted period of darkness of about one third of each 24 hour period so that hens may rest and to avoid problems such as immunodepression (Defra, 2002). Some also recommend a period of twilight of sufficient duration so that when the light is dimmed the hens may settle down without disturbance or injury (Defra, 2002). For cage systems this period may be 5 or 10 minutes whereas for non-cage systems longer periods (15 - 30 minutes) are used. In addition a period of twilight prior to the light period can reduce floor eggs, as modern hybrids often start laying eggs before dawn. If they cannot find the nest boxes in the dark they will lay their eggs on the floor if no twilight period is provided. Tanaka and Hurnik (1991) concluded that a simulated dawn and dusk could be more comfortable for the birds.

Birds need a certain minimum light intensity to find feed, water and nestboxes, to investigate their surroundings visually and to show normal levels of activity. There is no information on how much light this should be. Also it is not clear how birds

experience certain type of lights. It is known that the type of light source influences the amount of lux measured. Light sources used in poultry houses are often tungsten light bulbs or fluorescent light tubes, but also other sources are used.

Fluorescent light tubes can have a low (50-60 Hz) or high (100-120 Hz) flickering frequency. Nuboer et al. (1992) stated that hens can perceive the flickering of low frequency fluorescent light tubes and thus may experience discomfort. However, in a preference test comparing high and low frequency compact fluorescent lamps, Widowski and Duncan (1996) found that either birds did not perceive the flicker of low frequency fluorescent light or, if they perceive it, they did not find it aversive (also Manser, 1996).

## 10. FOOD SAFETY AFFECTED BY DIFFERENT PRODUCTION SYSTEMS

### 10.1. Introduction

Laying hens are kept to produce eggs intended for human consumption. Two categories of egg products can be identified, namely: whole eggs marketed for direct consumption or use in domestic preparation, and egg products comprising, either separate products (yolk and albumen), or a mixture of these 2 components. Most of the latter products undergo thermal treatments (pasteurisation) or desiccation and are mainly intended for the industrial preparation of a variety of foods (pastries, dairy products, etc). The number of eggs intended for processing by the food industry is approximately 25% and is escalating in the EU. At present most of these eggs are produced in battery cages, while eggs produced using NCs are mostly sold for direct human consumption.

The existing European legislation with reference to the control of zoonoses (Regulation no. 2160/2003 and Directive 2003/99/EC) and on food hygiene (Council Directive 89/437/EEC) is in place to prevent and control bacterial contamination along the egg food chain production, from the farm to retail shops and food processing plants. In that way, microbial criteria on eggs and egg products and good hygienic practices in packing centres and in processing plants should guarantee the safety of the products.

At the farm level, in the new European regulation (no. 2160/2003) on the control of specified zoonotic agents several serovars of *Salmonella* spp. are considered to have public health significance; among these *S. Enteritidis* and *S. Typhimurium* are regarded as the primary targets. Attention will be focused, first on breeding flocks of *Gallus gallus*, then on laying hens, broilers, turkeys, and finally slaughter pigs. However no reference is made to differences related to the system of egg production.

Concerning marketing standards of eggs, for example, Regulation no. 2295/2003, defines 2 grades of eggs (A and B) according to different physical characteristics as follows: (i) Grade A eggs ("fresh eggs") should have a "normal, clean and undamaged" shell and cuticle; they will not be washed or cleaned before or after grading, and will be not chilled or treated for preservation. The latter eggs require to be labelled and can be marketed as "washed eggs" or "chilled eggs"; (ii) Grade B eggs, i.e. eggs "which do not meet requirements applicable to eggs in grade A". Such eggs may only be used by the food or non-food industries.

Whatever is the destination of the egg, the producer should guarantee some quality features such as different physical, chemical and hygienic parameters. Meeting these quality criteria is dependent upon the implementation of the best zootechnical practices and sanitary rules.

## 10.2. Microbiological hazards in egg production

With regard to hygienic and sanitary qualities, it is important to produce eggs that do not present any health risk for the consumer. It is recognised that eggs and egg products are one of the main sources of food borne outbreaks in Europe (Humphrey, 1994), notably because of the presence of *Salmonella* Enteritidis in these products. There is no information available at present on the origin and type of production of eggs, and their subsequent egg products, contaminated by *Salmonella* spp. or involved in human salmonellosis.

It is recognised that "the content of an egg laid by a healthy hen is sterile". However, *S. Enteritidis* is sometimes found in the yolk of the egg before it is laid. This vertical transmission results from infection of the reproductive organs of the hen, in most of cases, without showing clinical signs (ACMSF, 1993; Gast, 1994).

Such infection appears to be very much lower in breeding flocks than in production flocks all over Europe (Evans and Pascoe, 2000). This suggests that horizontal transmission is the main mode of *Salmonella* infection for flocks. These bacteria may be present in large numbers in the layers' environment (Banhart et al., 1991; Jones et al., 1995), and may survive 57 days in poultry manure and between 382 and 1484 days in dust, depending on the serovar involved (Böhm, 2002).

The relationship between *S. Enteritidis* and the network of egg production has required the introduction of measures to limit its occurrence by the application of efficient biosecurity measures, and the sanitary slaughter of the contaminated flocks, or other measures such as vaccination, applied in some countries at the breeding as well as the production level.

A recent WHO/FAO (2002) report on risk assessment of *Salmonella* spp. in eggs and broiler chickens calculated these risks from different levels of prevalence in laying flocks and several possible intervention measures. The use of dirty eggs, especially if soiled with faeces, and cracked eggs, either for processing purposes or for direct consumption, increases the risk of *Salmonella* spp. penetration into the egg. Henzler et al. (1998) found that the only variable strongly associated with the production of *S. Enteritidis*-contaminated eggs was a high level of contaminated droppings and that a flock thus exposed was 11 times more likely to produce *S. Enteritidis*-contaminated eggs than a flock with a lower level.

Todd (1996) performed an analysis to determine the probability of illness associated with consuming cracked shell eggs in Canada. The number of cracked shell eggs was estimated by multiplying the fraction of all eggs that were cracked (between 1.6 and 6.3% of eggs examined in Canada) by the number of eggs produced annually in that country. To determine the illness burden, 13 outbreaks involving shell eggs were analysed and 5 of the outbreaks were identified as associated with cracked eggs. Given the estimated ratio of cracked to uncracked eggs, and the ratio of outbreaks associated with cracked eggs to those associated with intact eggs, a relative risk of 23:1 was calculated, which might range between 3 and 93 times more. By using reported human cases, Todd (1996) estimated that in Canada, 10,500 cases per year were associated with cracked eggs. The risk of illness was calculated as one case per 3800 cracked eggs consumed, using an estimated exposure to 40 million

cracked eggs. *Campylobacter* spp. was isolated from the eggshell in 2% of the 1200 eggs tested in Germany (EC, 2004). However, according to the research work reviewed by the ICMSF (1998), transmission of *Campylobacter* spp. (mainly *C. jejuni* and *C. coli*) by eggs is not probable, for a number of reasons: e.g. layers experimentally infected and actively excreting micro-organisms laid less than 1% of eggs contaminated on their surface. However, in such cases *Campylobacter* spp. disappears quickly from the shell in the normal storage conditions of temperature and relative humidity. It is also believed that this bacterium has a limited ability to penetrate into the albumen of the hen's egg.

Other foodborne bacteria of public health concern, such as *Listeria monocytogenes* and verotoxigenic *Escherichia coli*, have not been associated, to date, to disease outbreaks involving eggs or egg products.

Irrespective of the system of production use, the surface of the egg becomes contaminated very quickly after laying (Mathes et al., 1985). Contamination on ostensibly clean eggshells, as well as the percentage of dirty eggs, may show a linear increase if excreta moisture is increased (Smith et al., 2000). The dominant contaminants on the shell tend to be Gram-positive cocci and bacillus such as *Micrococcus* spp. and *Arthrobacter* spp., respectively, while egg contents are primarily contaminated by Gram-negative bacteria, such as *Alcaligenes* spp., *Achromobacter* spp., *Pseudomonas* spp., and *Escherichia coli* (Hutchinson et al., 2003).

At the moment it is not known whether the differences in bacterial numbers or species amongst eggs produced in different housing systems that have been obtained in a number of scientific studies could impact the egg product industry and product quality. Only one scientific report has indicated a direct relationship between initial egg contamination and that is later found in egg products (Pettrak et al., 1999).

### 10.3. Chemical hazards in egg production

There are a number of potential chemical hazards that may lead to egg contamination:

a) Presence of dioxins, dibenzofurans, PCBs and other persistent organohalogen compounds:

Persistent organohalogen compounds – like DDT, dieldrin, HCB, PCBs, and also dioxins and dibenzofurans – will be present mostly in fat rich animal feeding stuffs and via that route reach the animals (Kan, 1991, 1994). The control of these point sources has been reasonably successful over the years (Kan, 2002) leading to much reduced residues. The remaining issue of reducing residues resulting from environmental contamination (soil, treated wood etc.) is much harder to accomplish.

b) Non-organochlorine pesticide and heavy metal residues:

The persistence of the non-organochlorine pesticides used in plant pest control like the organofosphorous and carbamate ones, in both the environment and in warm

blooded animals is not high and hardly any residues can be anticipated in products of animal origin (Kan, 1994).

The most notorious heavy metals - lead and cadmium - when present in the feed of laying hens do not induce higher levels in eggs.

c) Mycotoxins:

Mycotoxins like aflatoxin, ochratoxin and zearalenon can occur in animal feed due to fungal action during growth or storage of plants or plant material to be used for poultry feeding. Carry-over from feed to eggs of these potentially dangerous substances has been shown to be quite low or non-existent (Kan et al., 1989).

In theory, the first hazards may be more prevalent in eggs produced in alternative systems, due to the reported higher incidence of bird pathologies, especially parasitic infestations. Recirculation of unwanted substances like drugs or coccidiostats via contact of the animals with their excreta is also more likely to occur in eggs produced in them (Friedrich et al., 1984). Contamination of the soil by chemicals, thus posing a potential risk for transfer into eggs, is also possible in free-range systems, if farms are located near to contaminated industrial or agricultural facilities. However, data on these subjects are scarce, and they will be discussed later.

## **10.4. Egg Safety in Conventional and Furnished Cages**

### **10.4.1. Downgraded eggs and associated risks**

There is much information on the effects on egg quality of some cage structural features, i.e. wire thickness and quality, slope of the floor, presence of egg baffles and the space per bird (Oosterwoud, 1987; Brake and Peebles 1992; Alvey and Tucker, 1993; Carey et al., 1995). Furnished cages (FCs) also feature these factors. In recent years the designs of these cages have radically changed, and so, the negative results seen in the first “get away” cages have been much improved (Wegner and Rauch, 1986; Wegner, 1990; Abrahamsson et al., 1995).

In FCs there are several factors that may affect the production of downgraded eggs: use of nests (depending on their design and position in the cage), cleanliness of nest mats, dust bath design and management, position and design of the perches and space per hen and group size.

Nevertheless, several more recent designs of FCs also have shown defects. Thus in some prototypes, eggs cracked more easily (Abrahamsson and Tauson, 1995; Alvey et al., 1996; Elson, 1999; Tauson et al., 2003), and in other models there was an increase, sometimes very high, in soiled eggs (van Niekerk and Reuvekamp, 1997, 1999; Fiks-van Niekerk et al., 2003). On the contrary, there are commercial models today which provide very similar egg quality traits after candling and sometimes even better ones than conventional cages (CCs) (Tauson, 2003). These models most often include details of designs, e.g. in nests, which have been proven crucial in order to give acceptable results. Some examples given by Wall and Tauson (2002) mostly relate to nest design and reduced speed of egg out-rolling from nests in FCs where eggs are accumulated in a narrow area compared to that in CCs.

It has been argued that the egg is a daily marker of the interaction between the bird and its environment (Solomon and Fraser, 1998); thus, the changes at such level could be as or even more useful than other features to assess the welfare of laying hens. This would be especially true for eggshell strength and integrity (Belyavin et al., 1991). Both features are of paramount importance from the point of view of egg safety.

There are some reports where eggshell strength features were reduced when using some models of FCs. Use of perches and increase of space per bird improved the shell structure (Solomon and Fraser, 1998), but if perching space was small, structural defects increased in eggs from cages with perches (Bain and Fraser, 1993), perhaps due to stress originating from competition for perching space. Competition for access to nest may cause paler brown eggshells due to deposits of extra-cuticular and amorphous calcium carbonate (Walker and Hughes, 1998), which are believed to be related to stress in birds (Mills et al., 1987); however, Yue and Duncan (2003) did not find differences in the frequency of these abnormal shells in white eggs laid in cages with or without nests, or with restriction of access to nests. Short et al. (2001) suggested that competition to access the dust bath could produce some degree of stress in hens, which reduced eggshell density.

Cepero et al. (2000a, 2001a, 2003) performed extensive analysis of eggshell thickness and density throughout two laying periods and they found that cage type had no effect on these shell features; thus, hens housed in FCs did not produce stronger or less defective shells. Genetics had much greater and very significant effects in shell yield and thickness. Mallet et al. (2003) obtained similar results. In addition, Guesdon and Faure (2004) did not find significant differences in direct measures of eggshell resistance to breakage, while shells from CCs showed a better resistance to deformation than those produced by hens housed in FCs.

Increases in dirty and cracked eggs have a negative impact on the economy of producers, and are also associated with potential risks to egg safety if egg inspection and grading is not properly performed. Of particular concern is the presence of hairline cracks in the eggshell, a defect that is only noted if eggs are candled. Several authors have reported significant increases of this defect in eggs collected in FCs (van Niekerk and Reuvekamp, 1999; Cepero et al., 2000a, 2001a; Appleby et al., 2002; Mallet et al., 2003; Guémené et al., 2004). Online grading may detect less hairline cracks than if grading is performed by hand (Abrahamsson and Tauson, 1993), especially in some grading machines running at high speed. Effective means to reduce the proportion of cracked eggs in models of FCs have been reported by Wall et al. (2002).

Nest boxes. According to recent reports, 85-95% of eggs are laid in the nests, and in some models often close to 100% (Tauson and Holm, 2002; Abrahamsson and Tauson, 1997; Walker and Hughes, 1998; van Niekerk and Reuvekamp, 1999; Fiks-van Niekerk et al., 2003). Use of nests by the birds seems to be affected by several factors, e.g. genotype (Abrahamsson et al., 1996) rearing conditions (Hughes et al., 1995), age at transfer (Sherwin and Nicol, 1993a), and age of hens (Alvey et al., 1996).

Good use of nests is of paramount importance to avoid an excess of downgraded eggs (Guesdon and Faure, 2004; Guémené et al., 2004). In some experimental prototypes of FCs, due to their inadequate design or position, hens used nests less than in other designs and there was a three times higher percentage of broken eggs than normal (Alvey et al., 1996; Walker and Hughes, 1998; Wall et al., 2002). Eggs laid outside the nest box show more soiling and cracks (Appleby et al., 2002; Guesdon and Faure, 2004), and this amount is very variable depending on the model of FC. In a French report, 7-43% of eggs were laid in the dust bath, and 6-25% on the wire floor of cages, which is not acceptable (Guesdon and Faure, 2004). These results contrast with those found in other experiments, where in most FC designs, eggs laid in the dust bath did not exceed 5%, except in only one model (Appleby et al., 2002), or did not exceed 1% (Tauson and Holm, 2002). Generally, if the closing mechanism is appropriate in design and well managed, the proportion of eggs in the dust bath is negligible.

However, nests are also a potential risk for the eggshell cleanliness, since in most current models of FCs, they are continuously opened and not closed automatically, and a certain percentage of hens, near to 10%, may sleep inside them (Appleby et al., 1993; Abrahamsson and Tauson, 1993; María et al., 2001), thereby soiling the nest mat. In fact, the percentage of dirty eggs has been found to be higher in FCs than in CCs in the majority of recent experiments (Cepero et al., 2000a, 2001a, 2003; Appleby et al., 2002; Mallet et al., 2003; Guesdon and Faure, 2004; Guémené et al., 2004; van Niekerk and Reuvekamp, 1997, 1999; Fiks-van Niekerk et al., 2003). Relative differences range from 10 to 30%, although much better results were obtained in some FC models with improved design (Tauson et al., 2003; Guesdon and Faure, 2004; Guémené et al., 2004; van Niekerk and Reuvekamp, 1997, 1999; Fiks-van Niekerk et al., 2003).

Dust baths. To avoid or minimize the risk of eggs being laid in the dust bath it is necessary to restrict access to after 8-9 hours after lights on in a full light program (Tauson, 1998). If the bath is managed in this way, much less than 1% of eggs will be laid in this area, which is probably the upper limit for acceptable results (Abrahamsson and Tauson, 1997; Walker and Hughes, 1998). In litter boxes remaining opened all day, eggs laid on litter may rise to 3-5%, and even if there are closed entrance gates, some layers may learn how to open them to lay in (Appleby et al., 2002). The nest design is also of interest in relation to this subject; with a nest box floor of Astroturf the eggs laid in the bath may be lower than 0.1% (Abrahamsson et al., 1996). Competition of hens for nests may lead to an increase of eggs laid in the dust bath, if nests are not sufficiently attractive and/or the dust bath is not properly designed and managed (Guesdon and Faure 2004), and/or oviposition is concentrated within few hours, as observed in some layer hybrids (Joly et al., 2003).

Other features can contribute to an increase of dirty eggs, such as the design of the egg collection system, and the position of the dust bath over the egg conveyor belts, leading to frequent finding of sawdust on the eggshells (Cepero et al., 2000a).

Perches. Hens use perches widely (averaging 25% in the daytime and 90% during the night, (Appleby et al., 1992; Abrahamsson and Tauson, 1993). However, the introduction of this element only usually produces an increase in the amount of broken eggs when a nest is not present (Abrahamsson and Tauson, 1993; Glatz and

Barnett, 1996). If there is no nest, and depending on perch design, some hens may lay from the perches (9-31%, and even 80% in some designs), with the consequent risk of broken eggs (Appleby et al., 1998; Moinard and Morisse, 1998).

The perch position is an important factor. It should not be an obstacle for hens, as it appears when located in the middle of the cage. In this case, dirty eggs increase since layers walk less on the floor and some eggs may not roll out onto the collection belt; besides, the dirt on the cage floor also increases. At 12-13 cm from the back of the cage there are no broken eggs behind the perch (van Niekerk and Reuvekamp, 2000b). However, without a nest present it often remains a higher percentage of broken eggs than in cages without perches (Abrahamsson and Tauson, 1993; Glatz and Barnett, 1996; van Niekerk and Reuvekamp, 1999). Alvey and Tucker (1993) recorded 1.1% of broken eggs in CCs fitted with perches in different positions, 5.9% when the perch was 13 cm from the back of the cage, and 3.1% if placed at 18 cm from the back.

Since the 1996 report, significant progress has been achieved, and the results of some experiments in research facilities and in commercial production with FCs offer more acceptable figures for broken and dirty eggs (Wall and Tauson, 2002; Appleby et al., 2002; Tauson et al., 2003 and Wall et al., 2004b). However, most authors recognise that egg quality is still a weak point in several, but not all, models of FC, since at least 10-15% more downgraded eggs are obtained in some models (Cepero et al., 2000a; Fiks-van Niekerk et al., 2003; Guesdon and Faure, 2004). Thus, FC designs still need further improvements (Appleby et al., 2002; Tauson, 2003).

Cage manufacturers are still improving their current designs of FCs. The results obtained seem to vary considerably with their experience. Hence, it is obvious that results obtained vary considerably between countries in Europe. It may therefore take some time to solve the problems referred to above before they are introduced into all commercial models. Scientific evaluation of new models of FCs and research with any new housing system should be encouraged prior to commercialisation. This should include the egg quality obtained. Field studies, as performed in Sweden (Tauson and Holm, 2002; Tauson et al., 2002) where 30 % of the national flock (1.5 million layers) is already in FCs could be also useful, since in several current FCs the egg quality still remains a problem, which could increase when they pass from the experimental level to commercial practice (Drakley et al., 2002).

#### 10.4.2. Microbiological risks

In the reports published by Cepero et al. (2000a, 2001a) there were no differences related to cage type in counts of aerobic mesophilic bacteria, those being at an acceptable level ( $10^4 - 10^5$ ) in FCs as well as in CCs. Coliform bacteria were present on very few shells from eggs laid in CCs, but FC eggs showed a progressively higher contamination on their shells, increasing from 13% at the first phase of lay up to 41.5% at the end of the laying period. However, all these shells showed counts below 3 log units. Eggs presenting shell contamination by thermotolerant coliforms were found only in those from FCs, and they increased with age from 6.6% to 16%. There were no signs of coliform contamination in egg yolk or albumen. At the end of the laying period, small counts of mesophilic bacteria were found in 22% of eggs laid in FCs having nest mats scored as very dirty - with faeces and other organic material

(Cepero et al., 2001a). It is concluded that eggs laid in CCs demonstrated the best hygienic quality.

Mallet et al. (2003), de Reu et al. (2003), Tauson et al. (2003) and Wall et al. (2004b) found a slightly but significantly higher bacterial load on shells of eggs laid in FCs. Nevertheless, the microbial load recorded remained below 5-6 log units, sometimes below 3-4 log units, limits which could be considered to relate to egg shells with an “acceptable” hygienic quality (Sauveur, 1988, Tauson, 2003). The results obtained from different FC models varied considerably, and age-related effects were inconsistent.

In some models of FC, dustbathing is performed on mash layer feed (Appleby et al., 2002). This technique should be evaluated with respect to risks of bacteria cross-contamination among hens and hence its possible consequences on hygienic quality of eggs. The most convenient alternative to feed used in dust baths is sawdust.

In summary, eggs produced in CCs still show the best quality from a microbiological point of view.

## **10.5. Egg Safety in non cage systems**

### **10.5.1. Downgraded eggs (grade B) and risks associated**

A report published by Torges et al. (1976) found an average of 26% dirty eggs in free-range systems and backyard flocks. In the modern French free-range farms a mean of 10-12% of broken and 5-15% dirty eggs) was reported, while in CCs the average of downgraded eggs was 6.5%, including a 1-2% dirty eggs (Champagne, 1997, Champagne and Bernicott, 1999).

In NCs, floor laying (with the subsequent dirt and bacterial contamination) depends on many factors (Appleby, 1984); thus, the percentage of eggs laid on the floor can be very variable (in aviaries in particular) but in some instances it can reach quite high figures. Belyavin (1988) reported in U.K. aviaries, percentages higher than 10%, and Michie (1992) found a 2.8-9.3% in perchery systems. Abrahamsson and Tauson (1998) performed 5 different trials, obtaining figures for percentage of misplaced eggs between 0, 7% and 10,5%.

These figures may be reduced to 1-2% if nests are properly managed (Taylor and Hurnik, 1996) and attention is paid to rearing methods. Van Emous (2003) reported 2% (0.4-5.6%) of eggs laid on the floor in Dutch aviaries, compared with 3.5 % reported by van Horne (1996). In the newest facilities (< 3 years) floor laying was reduced to a 1.2%, indicating that several improvements in design and management of aviaries have been implemented. However, the percentage of Grade B eggs still is very variable. Michel and Huonnic (2003) found in aviaries a 7.5-15.4% of these eggs, compared to only a 3.9% of eggs laid in cages. On the contrary, Leyendecker et al. (2002a) obtained a smaller percentage of dirty and broken eggs than in CCs.

Concerning broken eggs, very variable levels have been reported in outdoor systems when compared to those from cages, between -7 and +9% (Sauveur, 1991). In many cases in NCs, there may be a lower level of broken eggs than in CCs (Villagr a et al.,

2003a). Some authors explained this fact because of a reduction in the shell structural defects, but in fact it has been demonstrated that hens housed on deep litter or with outdoor access produce eggshells with a worse structure of their mamillary layer. It has been argued that some egg quality features, such as the eggshell structure, could be useful as welfare indicators (Belyavin et al., 1991).

The shell structure of eggs produced in NCs has been found to be worse than in eggs from cages (Bain, 1992; Bain and Fraser, 1993; Fraser and Bain, 1994; Fraser et al., 1995), and thus they could have an impaired ability to stop the penetration of *Salmonella* Enteritidis into eggs (Nascimento et al., 1992; Fraser et al., 1995). Conventional eggshell strength measures of eggs laid in nests show results similar to eggs from CCs (Suto et al., 1996; Villagr a et al., 2003b), but shell structure and the percentage of cracked eggs are more variable (Solomon and Fraser, 1998).

It has been argued that in modern CCs, the main cause of cracked eggs could be the high level of insults experienced during automatic collection (Overfield, 1995). This risk may be lower in small-scale NCs. NCs provide a higher level of freedom for poultry, but they also encourage a greater degree of conflict within the flock, and the latter is not commensurate with "good" shell formation (Fraser et al., 1995). Solomon and Fraser (1998) suggested that more attention should be paid to the collection and packing process for eggs collected from NCs, and that more problems are seen in commercial practice than at an experimental level

#### 10.5.2. Microbial risks

In some early studies it was found that in free-range and backyard flocks more eggs with a high level of contamination were produced (Torges et al., 1976). They found on such eggs a high presence of coliforms which were also found in the egg contents. Matthes (1985) obtained very small differences in eggs recently laid, but the eggshell contamination increased during the subsequent 6 hours in the nest, emphasising the need to collect them frequently. The problem of the trend to higher egg shell contamination in eggs from non-caged hens may be controlled by good management practices, such as frequent egg collection from nests and disposal of floor-laid eggs (Sauveur, 1991), and proper light programmes (Fiks-van Niekerk et al., 2003).

In more recent experiments a higher contamination of eggshells with mesophilic aerobic bacteria was also observed in aviaries or percheries, when compared to eggs produced in CCs or FCs (Protais et al., 2003a, c, de Reu et al., 2003). The increase is about 1 log unit (up to 5), with much higher counts in those eggs laid on the floor (almost 7 log units). It should be noted that a poor relationship between visual soiling of eggs and shell bacterial load was observed. A correlation was found between air microbial load (by  $m^3$ ) and egg shell contamination, the former being around 100 times higher than in the experimental unit equipped with CCs (Protais et al., 2003 a, b; de Reu et al., 2003).

Michel and Huonnic (2003) reported a 15 times higher concentration of dust in aviaries than in cages (31,6 vs. 2,3  $mg/m^3$ ). However, Hauser and F lsch (2002) noted smaller air quality differences between NCs and CCs, the latest showing a 50% less dust/ $m^3$  and 10 times less microorganisms/l.

In other studies, the bacterial contamination of eggs produced in aviaries was also found to be higher than in CCs and FCs, but with large variation depending on the collection site (Cepero et al., 2002). Currently, eggs laid on the floor that are apparently clean and undamaged, can be sold together with other eggs. However, since these eggs have higher levels of contamination this presents a potential risk. Eggs laid in NCs could in theory present a higher risk of contamination by *Salmonella* spp., because of the greater exposure of layers and their eggs to environmental factors. However, there is little scientific information available on this subject.

Regarding exposure to *Salmonella* spp. in the NCs of egg production, contact of eggs and birds with faeces, infected rodents or other animal vectors, is more likely to occur than in the CCs. Such exposure, where present, could lead to a higher risk of *Salmonella* contamination in eggs from NCs, but at present the extent of such exposure, if present, is not known for certain, as discussed below.

A study recently published by the UK Food Standards Agency (FSA, 2004) did not find significant differences due to production system, in *Salmonella* spp. contamination on the shell, at the retail level, among 4750 samples of eggs produced either in cages (50%), deep litter (16.5%), free-range (16.9%) or organic systems (16.6%). The prevalence of *Salmonella* spp. was estimated to rise to 0.08% by egg and 0.34% by box of six eggs, that is 1 in 290, if shells positive to *S. Dublin* are excluded (which are thought the result of environmental or cross-contamination). On the contrary, the prevalence could rise to 0.51%,.

There is an increasing interest in exploiting natural genetic resistance to infection and disease (Barrow et al., 2003), since there are genetic differences among current layers in relation to the risk of *Salmonella* penetration across the shell (Jones et al., 2004). At the moment there is also a request from the European Commission to EFSA related to the use of vaccines for the control of *Salmonella* spp. in poultry (adopted on 21 October 2004).

Measures for *Salmonella* spp. control and eradication (cleaning and disinfection, biosecurity measures, sanitary slaughter of the contaminated flocks, vaccination...) are of particular importance in NCs of egg production, due to the greater risk of environmental infections.

An additional risk may be posed by the limited surveillance and control of small layer flocks and their products, as may occur in organic egg production (Wegener, 2002).

### 10.5.3. Chemical hazards

On November 24, 2004 DG SANCO presented an update of occurrence data provided by the member states on chlorinated dioxins, furans and dioxin-like PCBs in food (EC, 2004). Levels of dioxins and furans in conventionally produced eggs (cage eggs<sup>2</sup>) had a median value of 0.38 pg TEQ/g fat, and a 95<sup>th</sup> percentile of 0.83. For

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<sup>2</sup> Definitions and minimum requirements to be met by poultry establishments for the various egg farming methods (cage, barn, free range eggs) are laid down in Annex III of COMMISSION REGULATION (EEC) No 1274/91 of 15 May 1991 introducing detailed rules for implementing Regulation (EEC) No 1907/90 on certain marketing standards for eggs as last amended by Commission Regulation (EC) No 326/2003 of 20 February 2003, OJ L47, 21.2.2003, p. 31.

free-range, barn, and organic eggs<sup>3</sup> the median value was 0.58 pg TEQ/g fat, the 90<sup>th</sup> percentile 2.80 pg TEQ/g fat and the 95<sup>th</sup> percentile 3.36 pg TEQ/g fat. These results imply that cage eggs are usually far below the current limit value of 3 pg TEQ/g fat, but that almost 10 % of the

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<sup>3</sup> Organic or biological farming as referred to in COUNCIL REGULATION (EEC) No 2092/91 of 24 June 1991 on organic production of agricultural products and indications referring thereto on agricultural products and foodstuffs as last amended by Commission Regulation (EC) No 746/2004 of 22 April 2004, OJ L122, 24.4.2004, p. 10-15.

eggs produced in alternative systems exceed this limit value. Also the levels of dioxin-like PCBs are on average higher in free range, barn, and organic eggs (median: 0.34 pg TEQ/g fat: 95th percentile: 3.97 pg TEQ/g fat) than in cage eggs (median: 0.29 pg TEQ/g fat: 95th percentile: 1.13 pg TEQ/g fat).

These results confirm earlier observations published by the European Commission in 2000 in the report on SCOOP Task 3.2.5, Assessment of dietary intake of dioxins and dioxin-like PCBs by the population of EU Member States (EC, 2000).

It is unlikely that the higher PCDD/PCDF levels found in free range, barn and organic eggs can be caused by contamination of the feed. For both conventional and organic production systems feeding stuffs have to comply with Commission Directive 2002/32<sup>4</sup>. The control of feeding stuffs for organic and inorganic contaminants has been significantly extended during the past few years within the European Union.

Higher PCDD/PCDF levels in eggs from chicken in free range systems (barn, free range and organic farms) are most likely caused by soil or by contaminated shavings, used for beddings on the floor (produced from wood that was treated with pentachlorophenol which is known to contain significant amounts of dioxins and furans). Stephens et al. (1995) have shown that dioxins and furans are bioavailable from soil, and kinetic models developed by Schuler et al. (1997) show that animals foraging on soil with low PCDD/PCDF levels may bioaccumulate these compounds into eggs at concentrations exceeding EU maximum levels.

Levels of PCDD/PCDF in soil vary depending on the site. Low background levels as found in rural areas usually originate from long-range transport of air pollution. Higher levels resulting from local emission sources can be found in industrial areas.

The influence of environmental contamination on levels of PCDD/PCDF and PCB in free ranging chicken eggs was demonstrated in a survey in England and Wales where concentrations in eggs from smallholding farms close to a chemical waste incinerator were considerably higher than those found elsewhere (Lovett et al. 1998).

A recent report from the Food Safety Authority of Ireland (March, 2004), concerning a surveillance of levels of PCDD/PCDF and PCB in caged chicken, free-range, barn and organic eggs, concluded that there is no statistically significant difference between caged chicken and free range eggs. Higher levels, however, were found for some organic egg samples, but the number of samples was only 4 and therefore no

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<sup>4</sup> Directive 2002/32/EC of the European Parliament and of the Council of 7 May 2002 on undesirable substances in animal feed, OJ L140, 30.5.2002, p. 10-22.

statistical comparison could be made between organic eggs on the one hand and caged chicken as well as free range eggs on the other hand.

Information from Belgium (Schoeters, 2004) and The Netherlands (de Vries, 2002; Hoogenboom, 2004) indicates that also in eggs from free range chicken kept on soil that is considered to be non-contaminated (background dioxin deposition < 6 pg TEQ/m<sup>2</sup>) could have high levels of dioxins and furans, exceeding the current limit value. This is particularly the case for small farms or chicken from private owners.

#### **10.6. Risks associated with egg washing**

Due to the higher numbers of dirty eggs laid in badly designed or managed FCs and especially in NCs, it is foreseeable that the demand for egg washing practice may increase in the short term. A recent European regulation (Regulation EC 2052/2003) established that in Member States where egg washing was permitted, those egg packing centres authorised to wash eggs can continue to do so without downgrading eggs to the B category, until 31<sup>st</sup> December 2006. Meanwhile, the EFSA has been requested by the EC to produce a scientific report on the possible health risks of egg washing.

### **11. WELFARE ASSESSMENT OF THE DIFFERENT SYSTEMS**

The categories of risk (Column 1) have been taken from the text. Only categories that are important for welfare are incorporated.

Remark: Outdoor run has been scored as additional risk to indoor system, so should be added the relevant NC system.

In the Table below, each risk to welfare has been summarized on a scale describing its likely prevalence in a given housing system on a 6 point scale: Negligible, Very Low, Low, Moderate, High and Very High.

If prevalence varies greatly between flocks housed within a system, due to the unpredictability of the risk, or where there is evidence of large individual variation within a flock, this is indicated as: Variable

Where a problem has a high prevalence, but is also thought to pose a particularly severe threat to welfare, this is indicated with an asterisk.

Only the most relevant indicators from the preceding part of the report have been included.

The indicators that have been included have not been weighted. All are felt by the panel to be important.

Risk to Welfare	Conventional Cage	Furnished Cage		Non cage		Outdoor run	Comments
		Small FCs	Large FCs	Single level	Multilevel		
<b>Mortality</b>							
Beak trimmed	Low	Very low/Low	Low/Moderate	Moderate	Moderate	Moderate/High	
Non beak trimmed	Low-moderate	Low/Moderate	Low/Very high	Moderate/High	Moderate/High	Moderate/Very high	
<b>Health</b>							
Infectious disease and use of veterinary medical products (antimicrobials)	Low	Low	Low	Low Variable	Low Variable	Low Very variable	This refers to infectious diseases that pose severe risks to welfare – either in terms of their prevalence or severity of clinical effects
Parasitic disease and use of veterinary medical products, Antihelmintics and Coccidiostats	Low	Low	Low	Moderate/variable	Moderate/variable	Very High *	Depends on the possibility to use e.g. deworming programs or not without withdrawing eggs (This differs from country to country)
Osteoporosis/Low bone strength	Very High *	Moderate/High	Moderate	Low	Low	Low	
Fractures sustained during lay	High	No data		Very High *	Very High highest risk*	Very High *	
Fractures sustained during depopulation	Very High *	No data	No data	Moderate/High	High/Very high	Low	

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Risk to Welfare	Conventional Cage	Furnished Cage		Non cage		Outdoor	Comments
		Small FCs	Large FCs	Single level	Multilevel		
Crowding /suffocation	Negligible	Negligible	No data	Moderate Variable	Moderate/ Variable	Moderate/ Variable	
Predation	Negligible	Negligible	Negligible	Very Low	Very low	Low/ Moderate/ Variable	
Feather pecking in beak trimmed flocks	Low	Low/Moderate	No data	Moderate	Moderate	Low	
Feather pecking in non-beak trimmed flocks	Moderate/ High	Moderate/ Very high	No data	High	High	Moderate/ Variable	
Cannibalism in beak trimmed flocks	Low	Low/Moderate	No data	Moderate Variable	Moderate Variable	Moderate	
Cannibalism in non-beak trimmed flocks	Low/Moderate	Moderate/Very high	No data	Very High * Variable	Very High * Variable	Moderate Variable	Special risk when birds are close to the light source
<b>Behaviour</b>							
Fearfulness	Moderate/ High	Moderate	No data	Moderate Variable	Moderate Variable	Moderate	
Inability to perform nesting	Very High *	Low	Low	Low	Low	Low	
Inability to perform perching	Very High *	Low	Low	Low	Low	Low Variable	
Inability to perform foraging	Very High *	High/Moderate	Moderate variability	Low	Low Variable	Negligible	In FCs depending on the location, design and opening hours of the litter area and
Inability to perform dustbathing	Very High *	Variable	High/ Moderate	Low Variable	Low Variable	Low Variable	

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The declaration of conflicts of interests of all participants in this working group will be available on internet.

## APPENDIX: MORTALITY TABLES

Table 1.1: mortality results of recent experimental studies comparing FCs and CCs.

References	Systems	Conventional cages (CC)		Furnished cages (FC)			
Tauson and Abrahamsson, 1996	Description	Triotec, 4 birds/cage 600 cm <sup>2</sup> /bird, 162 cages		Victorsson 8 hens/cage, 600 cm <sup>2</sup> /hen + 150 cm <sup>2</sup> for nest/litter, 169 cages			
	Hens	Non BT LSL		Non BT LSL			
	Keeping	20-80 w.		20-80w.?			
	Comments	3 studies of 2000 hens		3 studies of 2000 hens			
	Mortality	Average 6.0% [3.9-9.3%]		Average 5.3% [1.5-11.3%]			
Abrahamsson and Tauson, 1997.	Description	Triotec, 4 birds/cage 600 cm <sup>2</sup> /bird, n= 162 cages		Victorsson 5 hens/cage	600 cm <sup>2</sup> /hen 6 hens/cage	Victorsson 7 hens/cage	600 cm <sup>2</sup> /hen 8 hens/cage
	Hens	Non BT LSL		Non BT LSL	Non BT LSL	Non BT LSL	Non BT LSL
	Keeping	20-80w.		20-80w.	20-80w.	20-80 w.	20-80w.
	Comments	Higher than in FC. (p<0.01)		In total 144 cages with FC			
	Mortality	5.2%		2.8%	3.3%	3.1%	2.8%
Wall et al., 2002	Description	Triotec, 4 birds/cage 600 cm <sup>2</sup> /bird, 162 cages		Victorsson 14-16 hens/cage, 600 cm <sup>2</sup> /hen + 150 cm <sup>2</sup> for nest/litter			
	Hens	Non BT HylineBrown or white/LSL		Non BT Hyline Brown or white /LSL			
	Keeping						
	Comments	No significant Difference					
	Mortality	2.8%		3.3%			
Guesdon and Faure, 2004	Description	5 birds/cage, 660 cm <sup>2</sup> /hen, 96 cages	6 birds/cage, 635 cm <sup>2</sup> /hen, 108 cages	7 birds/cage, 826cm <sup>2</sup> /hen, 72 cages	15 birds/cage, 1134cm <sup>2</sup> /hen, 24 cages		
	Hens	BT Isa Brown	BT Isa Brown	BT Isa Brown	BT Isa Brown		
	Keeping	18-70 w	18-70 w	18-70 w	18-70 w		
	Comments	Light : 8-80 lux	Light : 8-80 lux	Light : 8-80 lux	Light : 8-80 lux		
	Mortality	17%	21%	10%	11%		

References	Systems	Conventional cages (CC)		Furnished cages (FC)	
Cepero et al, 2000b and 2001b	Description	6 hens/cage, 550 cm <sup>2</sup> /hen, 42 cages	6 hens/cage, 550 cm <sup>2</sup> /hen, 42 cages	10 hens/cage, 750 cm <sup>2</sup> /hen, 24 cages	10 hens/cage, 750 cm <sup>2</sup> /hen, 24 cages
	Hens	BT Isa Brown	BT Hyline brown	BT Isa Brown	BT Hyline brown
	Keeping	21-85 weeks	21-85 weeks	21-85 weeks	21-85 weeks
	Comments	1h30 midnight lightning, 8-10 lux			
	Mortality	10.7%	15.1%	5.8%	10%
Cepero com pers	Description	6 hens/cage, 550 cm <sup>2</sup> /hen, 84 cages	6 hens/cage, 550 cm <sup>2</sup> /hen, 84 cages	MEC, 10 hens/cage, 750 cm <sup>2</sup> /hen, 39 cages	Aviplus; 10 hens/cage, 750 cm <sup>2</sup> /hen, 48 cages
	Hens	BT Isa Brown	Hyline Brown	BT Isa Brown and Hyline Brown	BT Isa Brown and Hyline White
	Keeping	18-78 w		18-78 w	18-78 w
	Comments	With or without claw shortener	With or without claw shortener	2 types of claw shortener	
	Mortality	Isa : 1.6% with and 3.96% without claw shortener 1h30 midnight lightning, 8-10 lux (for all hens)	Hyline : 0.8% with and 5.5% without claw shortener	Isa : 2.4%; Hyline : 2.2%	Isa : 3.3-3.9%; Hyline White : 5%
Tauson et al., 2003	Description	4 birds/cage, 600 cm <sup>2</sup> /hen		8 birds/cage, 750 cm <sup>2</sup> /hen	
	Hens	Non BT LSL and LB		Non BT LSL and LB	
	Keeping	20-80 w.		20-80 w.	
	Comments	No difference between hybrids in mortality			
	Mortality	5.4%		Average 5.2%	
Wall et al., 2004a	Description	4 birds/cage, 600 cm <sup>2</sup> /hen		8 birds/cage, 750 cm <sup>2</sup> /hen	
	Hens	Non BT Hyline White and Hyline Brown		Non BT Hyline White and Hyline Brown	
	Keeping	20-78 w.		20-78 w.	
	Comments	No difference between hybrids in mortality			
	Mortality	Average 10.7%		Average 4.0%	

Note : BT: beak trimmed; LSL; Lohmann selected Leghorn : LB: Lohmann brown . w : week.

Table 1.2 : mortality results of recent experimental studies with FCs.

References	Systems	FCs			
Van Emous et al, 2003	Description	Aviplus B Dutchman 10 hens/cage, 756 cm <sup>2</sup> /hen, 54 cages	Aviplus B Dutchman 10 hens/cage, , 756 cm <sup>2</sup> /hen, 36 cages	Layer commune Janssen 50 hens/cage, , 754 cm <sup>2</sup> /hen, 8 cages	Layer commune Janssen 50 hens/cage, , 754 cm <sup>2</sup> /hen, 8 cages
	Hens	LSL	LSL	Non BT LSL	Non BT LSL
	Keeping	18-74 w	18-74 w	18-74 w	18-74 w
	Comments	1 <sup>st</sup> trial	2 <sup>nd</sup> trial, very different results	1 <sup>st</sup> trial	2 <sup>nd</sup> trial
	Mortality	Non BT : 5%, BT 5.4%	Non BT : 16.1%, BT 22.2%	Tube light : 21.5%, HF-FL : 8%	Tube light : 25%, HF-FL : 17.9%
Van Emous et al, 2003	Description	Comfort Specht, 39 hens/cage, 761 cm <sup>2</sup> /hen, 9 cages	Comfort Specht, 39 hens/cage, 761 cm <sup>2</sup> /hen, 9 cages	Euromodell Hellmann 8 hens/cage, 825 cm <sup>2</sup> /hen, 42 cages	Euromodell Hellmani, 8 hens/cage, 825 cm <sup>2</sup> /hen, 42 cages
	Hens	Non BT LSL	Non BT LSL	Non BT LSL	Non BT LSL
	Keeping	18-74 w	18-74 w	18-74 w	18-74 w
	Comments	1 <sup>st</sup> trial	2 <sup>nd</sup> trial, different results	1 <sup>st</sup> trial	2 <sup>nd</sup> trial, different results
	Mortality	Tube light:40.2%, Yellow LED light:14.5%,White LED light:45.3%	Tube light:26.5%, Yellow LED light : 27.4%, White LED light: 57.3%	Comfort light : 4.7%, HF-FL : 15.3%	Comfort light : 18.1%, HF-FL : 19.4%
Van Emous et al, 2003	Description	Euro 2000 Meller, 20 hens/cage, 750 cm <sup>2</sup> /hen, 18 cages	Euro 2000 Meller, 20 hens/cage, 750 cm <sup>2</sup> /hen, 18 cages	Veranda vencomatic, 45 hens/cage, 797 cm <sup>2</sup> /hen, 8cages	
	Hens	Non BT LSL	Non BT LSL	Non BT LSL	
	Keeping	18-74 w	18-74 w	18-74 w	
	Comments	1 <sup>st</sup> trial	2 <sup>nd</sup> trial, different results		
	Mortality	No expel system : 14.4%, expell system : 19.4%	No expel system : 36.3%, expell system : 45.8%	No elevated perches : 5.6%, elevated perches : 9.4%	

Elson, 2004	Description	Patchett 7-10 hens/cages (609-870 cm <sup>2</sup> /hen), 2 different heights	Patchett 6-8-10 hens/cages (609-1010 cm <sup>2</sup> /hen), 2 different heights	Patchett 6-8-10 hens/cages (609-1010 cm <sup>2</sup> /hen), 2 different heights
	Hens	BT Isa Brown; Babcock 380	BT and non BT Babcock 380	Non BT Hyline Brown; Shaver Brown
	Keeping	18-72 w	16-35 w	18-72 w
	Comments	3000 hens for each of the 3 experiments		
	Mortality	No significant effect of stocking density ( 3% to 4.7%) and genotype. Significant differences between cage heights : 38 cm : 3.1% / 45 cm : 5.5%	No significant effect of stocking density ( 3.9% to 7.1%) and cage height. Significant differences with beak treatment: BT : 1.9% / non BT : 9.9%	No significant effect of stocking density (3.8% to 5.7%), genotype and cage height.

Note : BT: beak trimmed; LSL; Lohmann selected Leghorn LB; Lohmann brown : HF-FL: high frequency fluorescent lights. W: week

Table 1.3: mortality results of recent experimental studies comparing CCs and alternative systems.

References	Systems	CCs	NC systems
Tauson et al, 1999	Description	3 hens/cages, 640 cm <sup>2</sup> /hen, 144 cages	3 hens, 640 cm <sup>2</sup> /hen, 144 cages
	Hens	non BT LB	non BT LSL
	Keeping	20-80 w	20-80 w
	Comments	Significant effect of housing and genetic	
	Mortality	7.4%	7.9%
Michel and Huonnic, 2003 Michel, 2004	Description	5 hens/cage, 580 cm <sup>2</sup> /hen, 2 trials, 1072-1048 cages	2 Aviaries B Dutchman, 9 hens/m <sup>2</sup> , 2700-2560 hens/aviary, 2 trials
	Hens	BT Isa Brown	BT Isa Brown hens
	Keeping	18-68 w	18-68 w
	Comments	Light :9 lux, 2nd trial : mortality due to high temperatures	Light : 16 lux
	Mortality	1 <sup>st</sup> trial : 2.8%, 2 <sup>nd</sup> trial : 6.7%	1 <sup>st</sup> trial : 3.9-5.2%, 2 <sup>nd</sup> trial : 3.3-5.5%
Michel and Pol 2001	Description	5 hens/cage, 580 cm <sup>2</sup> /hen, 536 cages	5 hens/cage, 580 cm <sup>2</sup> /hen, 536 cages
	Hens	Non BT Isa Brown	BT Isa Brown
	Keeping	18-68 w	18-68 w
	Comments	Light :9 lux,	Light : 9 lux,
	Mortality	2.8%	1.9%
Wahlstrom et al, 1998a	Description	3 hens/cage, 640 cm <sup>2</sup> /hen, 144 cages	1 Aviary of 2700 hens, 9 hens/m <sup>2</sup>
	Hens	non BT LSL and LB	non BT LSL and LB
	Keeping	20-60 w	20-60 w
	Comments	Mortality for each hybrid is 11.3% for LSL and 20.5% for LB (significant effect of hybrid)	
	Mortality	10.6%	20.2%
			1 Aviary of 2700 hens, 9 hens/m <sup>2</sup>
			BT Isa Brown
			18-68 w
			Light : 16 lux,
			3.75%
			Lovsta aviaries, 175 LSL / 150 LB (7.2 / 6.2 hens/m <sup>2</sup> ), 4 aviaries
			non BT LSL and LB
			20-60 w
			Marielund aviaries, 290 LSL /245 LB (9.2 / 7.8 hens/m <sup>2</sup> ), 4 aviaries
			non BT LSL and LB
			20-60 w
			16.8%

Wahlstrom et al, 1998b	Description	3 hens/cage, 640 cm <sup>2</sup> /hen, 144 cages	Lovsta aviaries, 175 LSL / 150 LB (7.2 / 6.2 hens/m <sup>2</sup> ), 4 aviaries	Marielund aviaries, 290 LSL /245 LB (9.2 / 7.8 hens/m <sup>2</sup> ), 4 aviaires
	Hens	non BT LSL and LB	non BT LSL and LB	non BT LSL and LB
	Keeping	20-80 weeks of age	20-80 weeks of age	20-80 weeks of age
	Comments			
	Mortality	LSL 2,5%, LB 11.4%	LSL 4.9%, LB 45.3%	LSL 3.1%, LB 30.2%
Abrahamsson and Tauson, 1998	Description		1 Marielund aviary, 2500 hen house, 9.2 birds/m <sup>2</sup>	1Marielund aviary, 5000 hens
	Hens		Non BT LB	Non BT LSL
	Keeping		20-80w.	20-80w.
	Comments		1 batch of birds a 2500	5 batches a 5000
	Mortality		20.9%	Average 7.5%(4.0-15.6)
Abrahamsson and Tauson, 1995	Description	3 hens/cage, 640 cm <sup>2</sup> /hen, LSL, 144 cages	Lovsta aviaries, 175 LSL (7.2 / hens/m <sup>2</sup> ) 4 aviaries	Marielund aviaries, 290 LSL /245 LB (9.2 / 7.8 hens/m <sup>2</sup> ), 4 aviaires
	Hens	NBT LSL	NBT LSL	NBT LSL and LB
	Keeping	20-80w.	20-80w.	20-80w.
	Comments			Separate groups
	Mortality	5.1%	8.0%	LSL 6.2%; LB 35.3%
	Description	3 hens/cage, 640 cm <sup>2</sup> /hen, LSL, 144 cages	Lovsta aviaries, 175 LSL / 175 Dekalb (7.2 / hens/m <sup>2</sup> ), 4 aviaries	Marielund aviaries, 290 LSL /Dekalb (9.2 /m <sup>2</sup> ), 4 aviaires
	Hens	NBT LSL	NBT LSL and Dekalb	NBT LSL and Dekalb
	Keeping	20-80w.	20-80w.	20-80w.
	Comments		Separate groups	Separate groups
	Mortality	8.1%	LSL 16.3% Dekalb 15.4%	LSL 6.7% Dekalb 9.1%

Note: BT: beak trimmed; Lohmann selected Leghorn : LSL; Lohmann brown :LB

Table 1.4: mortality results of recent commercial operations with FCs and CCs.

References	Systems	CCs	FCs		
Tauson and Holm, 2002	Description		Victorsson, 8 hens/cage- 600+150 cm <sup>2</sup> /bird, 14375 cages		
	Hens		Non BT ISA, Hyline, LSL, De Kalb white; LB and Hisex Brown		
	Keeping		Until 74-80 w		
	Comments		20 flocks, 12 farms, 3900- 8600 birds/farm		
	Mortality		5,1% [3,1-9,4%]		
Tauson and Holm, 2003	Description		Big Dutchman Aviplus. 10 hens/cage. 600+150 cm <sup>2</sup> /bird, 21600 cages		
	Hens		Non BT ISA, Hyline and LSL white		
	Keeping		Until 70-80 w		
	Comments		18 flocks, 10 farms. 2100-21400 birds/farm		
	Mortality		6,5% [1,8-11,4%]		
Elson, 2004	Description	Patchett, 4 hens/cage	Patchett, 8 hens/cage	Big Dutchman cages, 20	Valli cages, 20 hens/cage,
	Hens	BT Hyline brown	BT Hyline brown	BT Hyline brown	BT Hyline brown
	Keeping	16-69 w	16-69 w	16-69 w	16-69 w
	Comments	All cages were in the same house			
	Mortality	3.99%	3.85%	2.17%	2.11%
Weber et al., 2003	Description	CCs	FCs	Aviary including. out-door run	
	Hens	Lohmann Silver	Lohmann Silver	Lohmann Silver	
	Keeping				
	Comments				
	Mortality	11.0%	8.7%	11.8%	

	Systems	CCs	FCs
Rauch, 2004	Description	Conventional cages	FCs 10-60 birds/cage
	Hens	Brown and white NBT and BT	Brown and white NBT and BT
	Keeping	pullets-68 w.	pullets-68 w.
	Comments	Reference from breeders	Average of 70,000 birds
	Mortality	Weighted average 5.1%	Average 5.2 + 2.2%

Note : BT: beak trimmed; LSL; Lohmann selected Leghorn LB; Lohmann brown . w: week.

Table 1.5: mortality results of recent commercial operations with NC systems (and CCs).

References	Systems	CCs	NC systems
Ekstrand et al., 1997	Description		Vencomatic aviary, 112,000 birds, 27 flocks
	Hens		Non BT Hisex, LB and ISA brown; De Kalb and LSL white
	Keeping		Until 58-80 w
	Comments		1100-9990 birds/aviary
	Mortality		9,8% [4-23%]
Ekstrand et al., 1996	Description		Oli-free aviary ,29,000 birds, 17 flocks
	Hens		Non BT Isa and Hisex brown Shaver, Dekalb and LSL white
	Keeping		Until 75-80 w
	Comments		550-2715 birds/aviary
	Mortality		15,8% [: 7-27%]
Tauson and Holm, 1999	Description		Marielund- Victorsson aviary, 99,000 birds, 21 flocks
	Hens		Non BT LSL and LB, SLU 1329
	Keeping		Until 52-80 w
	Comments		2060-8200 birds/aviary
	Mortality		8% [2-25%]
Jensen., 2003	Description	39 flocks/year; 700,000 birds. 600 cm <sup>2</sup> /bird,	Single tier litter floor systems, 7 birds/m <sup>2</sup> , 64 flocks/year. 500,000 birds
	Hens	BT white birds	BT brown birds
	Keeping	21-76 weeks	21-72 w
	Comments	1992-2002 in Denmark	1992-2002 in Denmark
	Mortality	5.1 % [4.0-6.3%]	9.9 % [8.7-12.1%]
Jensen., 2003	Description		Organic, 360,000 birds, 71 flocks/year
	Hens		Non BT Brown birds
	Keeping		21-68 w
	Comments		1995-2002 in Danemark
	Mortality		11.9 % [10.4-18.4 %]
			Free range. 23 flocks/year. 200,000 birds.
			BT brown birds
			21-68 w
			1995-2002 in Denmark
			9.5 % [7.7-11.4%]

References	Systems	CCs	NC systems
NFU, 2003	Description	CCs	Single level floor and free range
	Hens	BT Brown genotypes	
	Keeping	17-72 w	
	Comments		
	Mortality	5% [2-8%]	8% [3-12%]
Nicol et al. (in prep)	Description		Single level NC systems , 36 flocks
	Hens		Shaver Brown
	Keeping		From 20 until 70 weeks
	Comments		2450 – 4200 birds per flock, stocking density 7 to 12 birds m <sup>2</sup>
	Mortality		11.7% [6.9-21.4] Mortality was significantly higher at the lower stocking densities of 7 or 9 birds/m <sup>2</sup> , than 12 birds/m <sup>2</sup> .
Häne, 2000	Description		Deep litter systems, 11 Grid Floor systems, 29 Aviary systems, 28 flocks flocks
	Hens		White LSL, Hypex HN, Isa Brown, LB (around 60% BT)
	Keeping		Until 72 w, no access to free range area
	Comments		No significant difference between housing systems
	Mortality		0.75%+/-0.74 / 28 days mean : 9.8% for 52 w of laying 0.58 +/- 0.46% / 28 days mean : 7.5% for 52 w of laying 0.45% +/- 0.28 / 28 days mean : 5.9% for 52 w of laying

Note: BT: beak trimmed; LSL: Lohmann selected; Leghorn LB: Lohmann brown; W: week



**Annex of the Chapter 3 of the Scientific Report Welfare aspects of various systems for keeping laying hens.**

**Figures and pictures.**

**Figure 3.1: Furnished Cage for Small Group**

Litter box is on top of the nestbox

The perch is positioned parallel to the feed trough. The feed trough runs outside the cage. Underneath it is the egg belt.



**Figure 3.2: Furnished cage for small group (8 hens)**

Various behaviours in a furnished cage with 8 birds. One bird is in the litterbox, one bird is wing flapping and several birds are perching

**Figure 3.3: Furnished cage for small group**

Small group (8 hens) of medium brown hybrids in FC with hard wood perch, side nest box with Astroturf floor pad and litter dust bath box over the nest.



**Figure 3.4: Furnished cage for larger group**

Medium group of 20 hens. The nestbox is on the rightside at the back. Right next to it (not visible on this picture) is a litter area. In the lower cage the perches are clearly visible.



**Figure 3.5: Furnished cage for medium group size**

Medium sized group (18 hens) shown in a section of an FC with perches positioned at right angles to each other. This meets the EU Directive requirement of 15 cm/hen but the picture illustrates the fact that hens cannot actually use the total perch length provided.

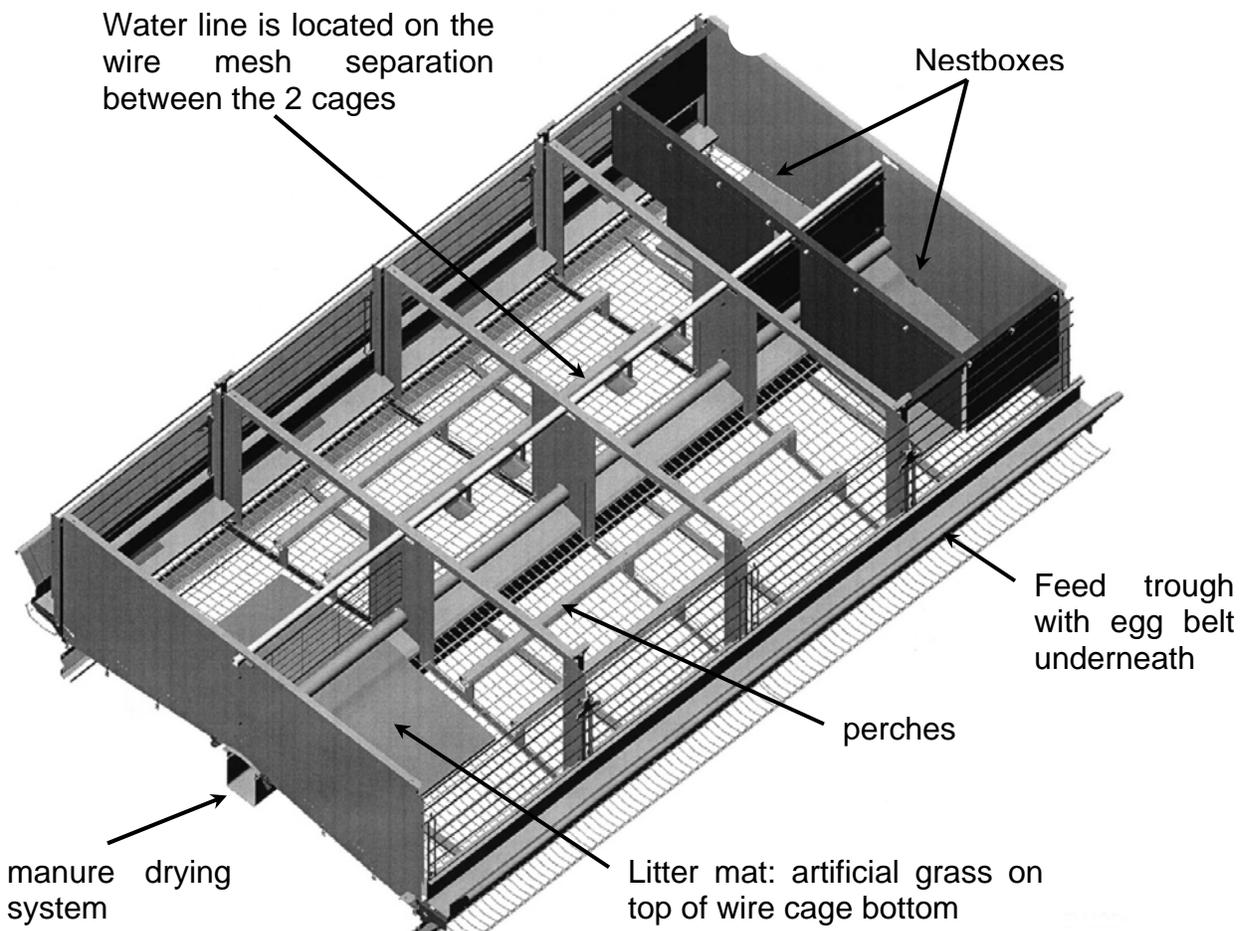


**Figure 3.6: Litter mat in furnished cage**

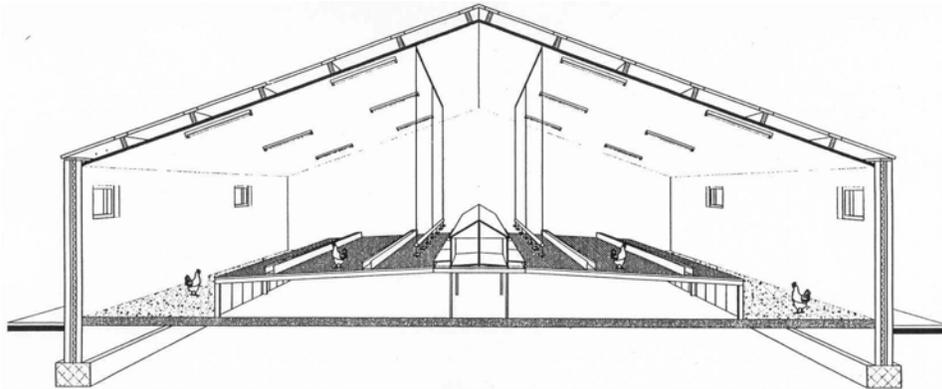
Litter mat with automatic litter supply (part of it seen at the top of the picture)



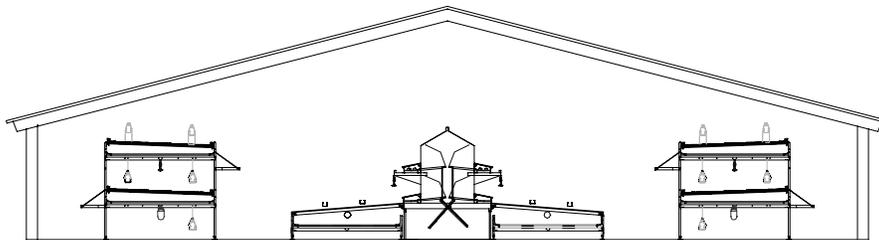
Figure 3.7: Schematic drawing of 2 large furnished cages



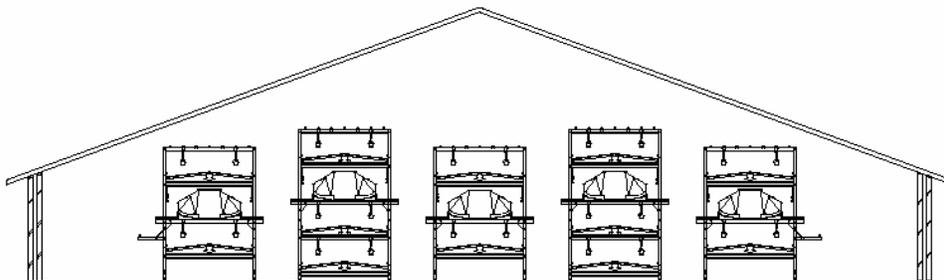
**Figure 3.8: Single tier alternative (non-cage) system**



**Figure 3.9: Aviary with non-integrated nest boxes**



**Figure 3.10: Aviary with integrated nest boxes**



**Figure 3.11: Portal aviary**

