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Integration of animal welfare into housing systems for laying hens

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Abstract

During the last 25 years poultry husbandry has strongly been intensified, dramatically changing the living conditions of the animals and generating fierce debate on animal welfare. The most severe criticism was on the battery cage housing system for laying hens. At present it is the policy of some European countries to ban the battery cage if appropriate alternatives become available. First the concept of welfare is elaborated and parameters for welfare are identified. Secondly, requirements for the housing of laying hens are defined and the strategy towards a new and better housing system is described. The present state of research, especially on the Tiered Wire Floor system, and constraints and perspectives are discussed.

Keywords: hens, housing, welfare

Introduction

In Western Europe the concern about the welfare of farm animals has increased considerably in the last 25 years, because of the strong intensification of animal husbandry systems, resulting in dramatic changes in the living conditions of the animals. Around 1960, laying hens in the Netherlands were still housed in small flocks of up to 600 hens, and there was ample space for the birds, inside as well as outdoors. Nowadays about 95% of the hens are housed in battery cages, which obviously provide very limited space and monotonous surroundings. Average flock size in 1989 was 14 000, while about 20% of the farms had more than 20 000 hens.

In the Netherlands, as in several other countries in northwestern Europe, these modern husbandry practices have generated fierce debates. Commissions of inquiry have been installed, such as the Brambell Committee in the UK (HMSO, 1965) and the Husbandry and Animal Welfare Committee in the Netherlands (NRLO-TNO, 1975). Mostly, criticism of modern production systems did not focus on the exploitation of animals as such but merely concerned the adverse effects on their behaviour and welfare. In the early years of the welfare debate, agricultural research had just started the exploration of this new field being not able to provide much information for this discussion. Nowadays, a considerable amount of scientific knowledge is available about the effects of housing on behaviour and physiology, and there is a theoretical framework relating these factors to the state of welfare of the animal (Broom, 1988; Wiepkema, 1985).

For laying hens, the main criticism is levelled at the battery cage system. Several European countries have legal regulation on the housing of laying hens in cages (e.g. Norway, Denmark), while some countries have even banned the cages (e.g. Switzerland). The European Community has specified strict conditions for battery cage housing (EEC directive 86/113/EEC). Moreover, the Council of Europe has drawn up a convention for the protection of animals kept for farming purposes (Council of Europe, 1976). In the framework of this convention, a recommendation concerning laying hens was adopted in 1986 containing the minimum demands of their welfare. Thus, birds should be able to stand normally, to eat simultaneously, to have access to at least two water nipples, etc.

The concept of welfare is elaborated in this article. Parameters to identify a situation of impaired welfare are discussed and requirements for the housing of laying hens are defined. The strategy to develop better housing systems is described, as well as the present state of the art and the constraints and perspectives.

Welfare

In many cases, ethical motives for the welfare of farm animals are based on respect for nature in general and living beings in particular. Other arguments are based on the assumption that animals have subjective experiences or emotions and can suffer. This assumption is reflected in some definitions of welfare, such as the one formulated by Lorz (1973): 'Es handelt sich um einen Zustand physischer und psychischer Harmonie des Tieres in sich und mit der Umwelt'.

In recent years, ethical views on animals have further developed, including that animals are recognised as having an inherent value and therefore moral status, by virtue of which they are worthy of moral respect. Treatment of animals and its effect on their welfare should therefore be evaluated and tested against moral standards and values. Although this testing is a matter of ethics and politics, the moral decision depends upon the availability of evidence about welfare (Broom, 1988; Duncan, 1981).

Earlier definitions of welfare were rather descriptive (e.g. Hughes, 1976; Lorz, 1973) and were therefore not an adequate scientific tool for assessing welfare of animals under different conditions. Later definitions refer to biological adaptation to or control of the environment by the animal and seem more operational (e.g. Broom, 1986; Baxter, 1983; Wiepkema, 1982). These definitions (Baxter, 1983; Broom, 1988; Wiepkema, 1985) start with the thesis that in the course of evolution every animal species has been adapted to a specific environment in which it is able to regulate its internal state, to survive and to reproduce. Regulatory systems in animals consist of active physiological and behavioural responses to changes in that environment, allowing the animal to keep internal and external conditions at an optimal level (Figure 1). The possibility for control is essential to animal life. Higher animals not only react to environmental changes, but are able to predict these changes and to

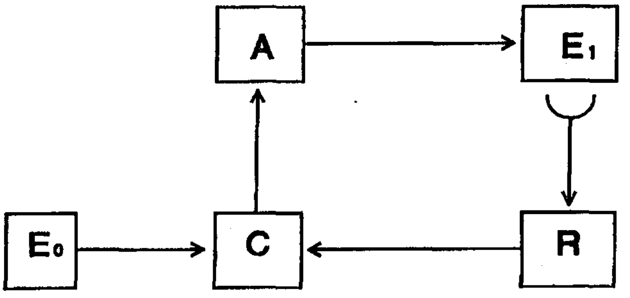

Fig. 1. Regulatory model (adapted from Wiepkema (1985)). Environmental factors E_1 (internal or external) are perceived with receptor R and compared with E_0 (set point). When E_1 differs from E_0 regulatory action (A) is taken to change E_1 in the direction of E_0.

anticipate. Reduced controllability or predictability of relevant environmental changes are the main cause of typical behavioural and/or physiological stress symptoms, such as elevated corticosteroid levels, stomach damage, conflict behaviours, etc. (c.f. Bohus et al., 1987; Seligman, 1976; Weiss, 1968; Wiepkema, 1985). It may also be described as a situation which does not correspond with the expectations of the animal and cannot be regulated effectively.

For appropriate behavioural or physiological reactions, it is important that the animal continually monitors the effectiveness of its regulatory actions. Wiepkema (1985) suggests that emotions or feelings are involved in this monitoring. Positive feelings are experienced when regulatory action is effective (high controllability/ predictability), and negative feelings are experienced when this is not the case, i.e. in a stress situation. In terms of this model an animal is stressed and its welfare is at stake when regulatory action, in relation to relevant environmental factors, is chronically hampered.

Parameters of disturbed welfare and the related housing requirements

Husbandry systems may hamper the animal's usual regulatory actions in several ways, for instance:
- Action is physically impossible because of a lack of room. It may result in intended escape responses.
- The goal object of a regulatory action (e.g. litter, laying nest) is absent or inadequate. It may result in redirection of the activity towards less adequate goal objects or conspecifics (redirected behaviour) or performance of behaviours without any appropriate substrate (sham behaviour).
- Inadequate group size or composition, which may result in increased aggression, escape behaviour and fear responses.

Thus, it may lead to several forms of abnormal behaviour, which may become ritualized in the form of stereotypies if conditions do not change (Ödberg, 1987;

Wiepkema, 1985). Abnormal behaviours, including stereotypies, are considered as reliable indicators of disturbed welfare (Wiepkema, 1982). Laying hens may show abnormal behaviours like feather pecking, sham dustbathing, hysteria, stereotyped pacing and stereotyped pecking (Ferguson, 1968; Wiepkema et al., 1983). Although the exact cause is not always clear, several housing conditions are known to affect the occurrence of these behaviours:

- *Space.* Because the structure and quality of space is also an essential factor, it is very difficult to evaluate the effect of limited space on the occurrence of abnormal behaviours. However, there is a clear tendency towards less abnormal behaviour (e.g. hysteria) when more room is provided.
- *Litter.* If litter is not provided, dustbathing behaviour is disturbed (Black & Hughes, 1974) while feather pecking is stimulated as a form of redirected ground pecking (Blokhuis, 1986; Blokhuis & Arkes, 1984).
- *Laying nests.* Disturbed pre-laying behaviour (stereotyped pacing) may occur when laying hens are not provided with nests (Wood-Gush & Gilbert, 1969).

So, sufficient space, litter and laying nests may be considered as essential requirements for the housing of laying hens.

Development of alternative housing systems

Some 15 years ago, research on alternative housing systems for layers started at the Centre for Poultry Research 'Spelderholt', in close cooperation with the Institute for Agricultural Engineering. The first goal was to develop a system covering the needs of the birds as well as demands in the field of hygiene, mechanization, labour conditions, productivity and cost price. Low NH3 volatilization has been recently added to this list of requirements, since NH3 emissions from animal husbandry are a major source of acidification in the Netherlands. The poultry share in the total emission of livestock production systems is 12%. Two lines of research were pursued. First we studied possibilities to develop an alternative cage system, and later we started research into the possibilities of improving the traditional deep litter system. In both lines of research we followed a similar strategy (Anonymous, 1988; Blokhuis & Haye, 1986; Ehlhardt, 1985a):

- Prototype housing systems were developed with laying nests, litter and more space for the hens compared to battery cages to accomodate their welfare. These were tested in small-scale, short-term experiments and repeatedly adapted. During this phase of trial-and-error research not many systematic observations were carried out.
- Promising prototypes were developed a step further. Behavioural studies were carried out and prototypes were checked on zoötechnical viability over a longer period, but still on a small scale. Studies were also made on construction parameters, labour conditions and possibility of mechanization.
- The best prototype was selected on the basis of an evaluation of the data from the foregoing phase (behaviour, zoötechnics, construction, labour and mechanization). This was tested on a semi-practical scale with systematic studies of labour conditions, production and health, etc. In this step, first comparisons with the

battery cage took place, including also an economic evaluaton.
- Finally, the system may be tested on a practical scale. This involves the cooperation of farmers installing and running the system.

Other research groups in Europe have been concentrating on other alternatives, like percheries, different types of aviaries, Hans Kier system, tiered terrace etc. An inventory of these systems may be found in Kuit et al. (1989).

Improved battery cage

In 1976 the British scientist Bareham published the design of an experimental cage for 6 hens. Birds were given more individual space compared to a battery cage, laying nests with litter and perches (Bareham, 1976). At the same time the cage should have the same advantages as the normal battery cage (hygiene, mechanization, manageability, high stocking density, etc.). A slightly different version of this cage was tested by Elson (1976), who called it 'get-away-cage'. This name refers to the possibility for the animals "to get away".

At the Spelderholt Centre, experiments with get-away-cages were started in 1975. Several designs were tested on a small scale and this resulted in the type as represented in Figure 2. Laying nests with litter were replaced by roll-away nests and a separate 'sand-box' was provided. This was done to discourage the birds to dustbath in the nest, which resulted in a lot of dirty and cracked eggs. To prevent animals from laying their eggs in the sand-box this had to be closed during the morning hours. This cage was intended to house 20 birds. From 1979 until 1983 it was tested on a semi-practical scale and compared with conventional battery cages and a deep litter system (Blokhuis & Haye, 1986).

The battery cages showed the best zoötechnical and economical results in all three

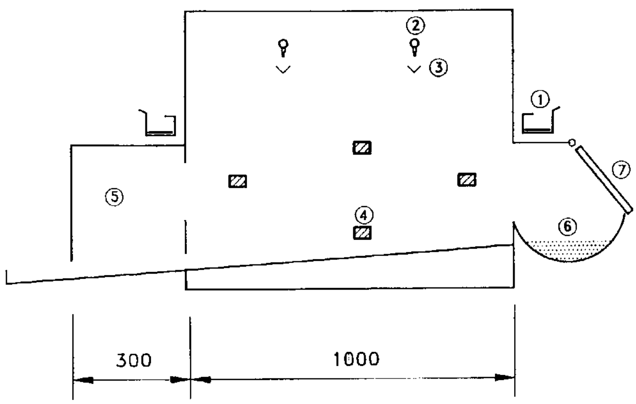

Fig. 2. Schematic representation of the 'get-away-cage' design as it was tested on a semi-practical scale. 1 = feed trough; 2 = drinking nipple; 3 = drip gutter; 4 = perch; 5 = laying nest; 6 = litter; 7 = valve.

experiments. Loss of eggs and the number of second-graded eggs was highest in the get-away-cages. Many eggs were laid in the sand-boxes. This problem was solved by opening the sand-boxes only during a few hours in the afternoon when more than 99% of the eggs are already laid. Other problems of the get-away-cage system concerned labour requirement and labour conditions. Much sand was lost from the sand-boxes and refilling was necessary. Surveyability was very poor, which hampered inspection and catching of the birds.

After three experimental runs on this scale, a new prototype of the get-away-cage was constructed and tested again on the smaller scale. However, too many of the problems of the previous type were seen once again. In view of the prospects for commercial application, in comparison with other alternative systems, it was decided to stop this line of research and to concentrate on an alternative of deep litter housing.

Deep litter system

The traditional deep litter system fulfils many of the requirements of the birds' welfare. There is more freedom of movement, there is litter for dustbathing, scratching and pecking, and there are laying nests. However, in several aspects important for the cost price of eggs, such as housing density of birds, labour costs, labour efficiency and managability, the deep litter system is deficient. The egg producing industry in exporting countries, like the Netherlands, are therefore not inclined to accept the system as a real alternative to battery cages. With the deep litter system in mind, a new system should be developed, which combines the beneficial effects on the hens' welfare of the deep litter house with the efficiency and managability of the battery cage system.

Tiered-wire-floor system

In 1981 we started a joint project to develop an improved deep litter system. Initially, several concepts and prototypes were tested at the Spelderholt Centre on a small scale. The result was a promising design, called tiered-wire-floor (TWF) system (Ehlhardt, 1985a; Ehlhardt, 1985b). The basic layout of this system is illustrated in Figure 3. It consists of scaffoldings with three tiers of wire platforms, arranged length-wise in the house, alternating with passageways. Feed is available on the two lower platforms and water on all three. Perches are mounted over the top tier. The whole floor of the house is covered with litter and the hens have access to the litter from all tiers of wire floors. The laying nests are placed in the middle and along the walls of the house. Manure belts run under the wire platforms. Perforated air tubes alongside the belts are used for drying the manure in order to reduce the ammonia volatilization. There are about 20 hens per square metre house, i.e. about 8 birds per square metre available floor space.

This prototype was tested on a small scale in longer trials, including experiments with the tiered wire construction and the mechanical removal of manure and eggs. The results were very promising; good production with a low percentage of floor

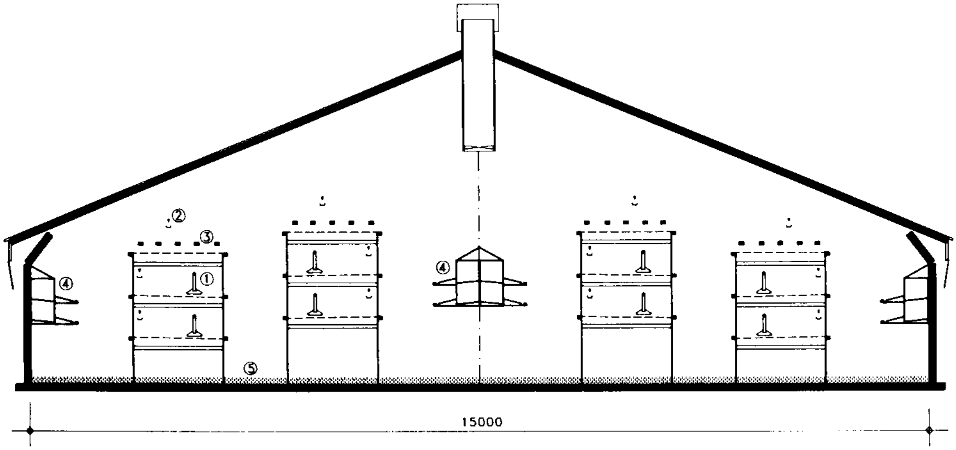

Fig. 3. Schematic representation of the Tiered Wire Floor system. 1 = feed trough; 2 = drinking nipple; 3 = perch; 4 = laying nest; 5 = litter.

eggs seemed feasible and welfare requirements seemed to be fulfilled. In 1988 a test started on a semi-practical scale with a flock of 6 500 birds compared with a similar flock in a common three-tiered battery cage system in the same building. Production results of the first laying cycle are presented in Table 1. These results look promising for the system although the percentage of floor-eggs remained too high and the labour requirement was 70% higher (Ehlhardt et al., 1989). Dust concentration measurements indicated a poor air quality in the TWF system; total dust was 13.43 mg m^{-3} of air compared to 1.12 mg m^{-3} in the battery cage house. The cost price of the eggs was estimated to be about 9% higher compared to battery cage eggs. This work is still in progress; the third laying cycle just ended.

Observations showed that specific behavioural patterns like dustbathing were not disturbed in the TWF system, while in battery cages dustbaths were shorter and often

Table 1. Production results from the first laying cycle of a comparison of the TWF and battery cage system (laying period 20-76 weeks of age). Derived from De Wit et al. (1990).

	Battery	TWF
eggs per hen housed	322	321
laying percentage	84.5	84.6
average egg weight (g)	62.2	60.7
egg mass per hen housed (kg)	20	19.5
percentage floor eggs	–	5.0
percentage second grades	6.5	3.8
feed consumption per hen per day (g)	115	116
feed conversion	2.20	2.27
mortality (%)	5.6	6.4
average hen weight at 76 weeks (kg)	1.794	1.756

incomplete. Also in the TWF system, dustbathing was concentrated between 6 h and 12 h after light onset, whereas in battery cages dustbathing was seen from 5 h after light onset until the end of the photoperiod (Rommers et al., 1991). Behavioural studies in small units with the TWF system also showed that the hens made proper use of the whole system and its facilities (Blokhuis & Rommers, 1989). The spreading of the hens over the TWF system was studied in four similar units between 9.00 h and 10.30 h and between 15.15 h and 16.45 h. The average spreading based on these studies is shown in Figure 4. The perches located on the top tiers of the system are used intensively by the hens, particularly at night. Some observations during this period showed that almost all hens sleep on these perches. During daytime, about 60% of the perching time a hen is preening or resting. About 30% of the time on litter was spent pecking and scratching and dustbathing.

In 1990, the first tiered-wire-floor system, with 20 000 hens, was installed on a practical farm. In 1991, two more followed, one with a (slightly different) design as presently used in Switzerland, and will be tested under practical conditions. Apart from the research program several other farms will be equipped with comparable systems in the near future.

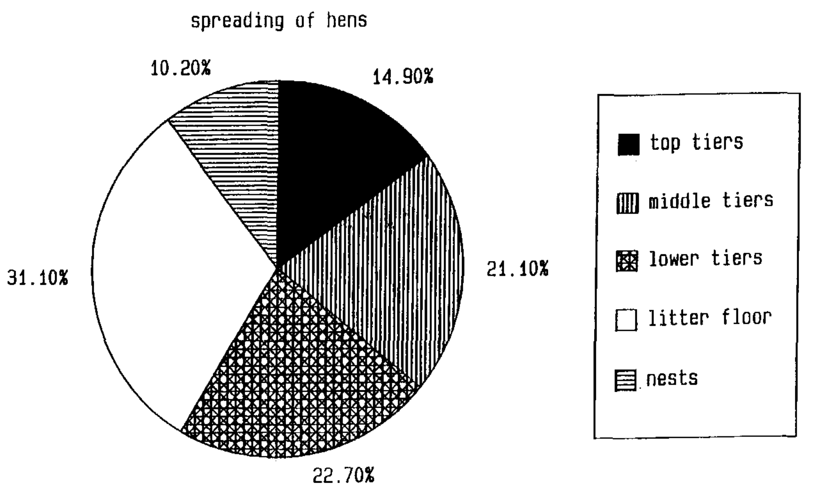

Fig. 4. Average spreading of hens over the TWF system based on observations in four similar units between 9.00 h and 10.30 h and between 15.15 h and 16.45 h. (from Blokhuis & Rommers, 1989).

Bottlenecks and perspectives

At present, the perspective of an alternative cage housing system like the get-away cage is estimated as being low. Practical problems arise from the presence of litter or sand in these small units and problems exist with surveyability and inspection of the birds. Also from a welfare point of view, these systems are likely to be inferior to other alternatives such as the TWF system.

Although the TWF system seems to have better perspectives than the deep litter system in terms of management and production costs, it still cannot compete with the battery cage in economic terms. An option is that eggs from alternative systems are sold as a special brand and at a higher consumer price, as is done for deep litter and free-range eggs. This approach may have some success and thereby improve the living conditions for a part of the laying hen population. Thus, if a complete move towards welfare improving systems like TWF is required, it is needed to ban the cheaper but, in terms of behaviour and welfare, deficient battery cage system by law. If this legislation is implemented by the European Community, egg production with such systems is also feasible for the egg exporting countries.

Whether systems like the tiered-wire-floor system are suitable for production on a scale comparable to that of battery cages is still open for discussion. At least farmers with large flocks in such systems should be extra alert to the spread of diseases and the development of cannibalism (Hughes, 1990; Elson, 1990). Moreover, proportional to the flock size the labour demand for collecting floor eggs is increasing. A rough estimation is that 2-5% of the eggs will be laid outside the nests on the wire floors or on the litter. These eggs must be removed several times a day, especially at the start of the hens' laying cycle. An egg may stimulate a bird to lay its egg next to it and this may increase the problem of floor eggs.

Inside the hen house, a worker is likely to be exposed to a high concentration of aerial dust. The presence of litter on the floor and air movement because of flying birds are among the causes of this high concentration as compared to battery cages. The use of dust masks will be obligatory, if the dust problem is not solved in another way. Preliminary studies did not show any detrimental effects of dust on the birds' lungs. In a housing system with litter, ammonia emission is less easy to control than in systems without. This is or might be another drawback of alternative housing systems. Nevertheless, this problem may be solved more easily, e.g. by drying and ventilation techniques, than the dust and labour problems.

In conclusion, aviary housing systems like the TWF meet to a considerable extent the behavioural needs of the hens and seem promising in terms of egg production. However, until now there have been serious drawbacks in terms of labour requirements and labour conditions, disease control and risk of cannibalism to be solved, while there is also the higher cost. Only under protected market conditions, are alternative systems likely to survive in economical terms.

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