SHOULD CAGES FOR LAYING HENS BE BANNED OR MODIFIED?

M C Appleby

Institute of Ecology and Resource Management,
University of Edinburgh, West Mains Road, Edinburgh EH9 3JG, UK

Abstract

Conventional cages for laying hens have many disadvantages for welfare and there have been widespread calls for them to be banned. However, they also have advantages: in particular, they house the birds in small groups. Modified designs intended to reduce the disadvantages while retaining the advantages have included the get-away cage (providing perches and other facilities for up to 60 birds), but these designs have not yet had much success. The Edinburgh project on modified cages has adopted a stage-by-stage, systematic approach to cage design. Recommendations include increased area and height compared to conventional cages, and inclusion of a perch, a nest box and a dust bath. Current trials combine all these features in designs with commercial potential. One remaining welfare problem is restriction of locomotion, with associated effects on bone strength. However, alternative, non-cage husbandry systems for laying hens also have welfare problems, including those associated with large group sizes, and these problems may be worse than those in modified cages. Probably most important is the risk of cannibalism - or the practice of beak trimming to prevent it. Rather than banning cages, it might be more appropriate for legislation to specify the facilities which should be provided for laying hens.

In the current state of development of alternative systems, modifying cages for laying hens could on balance be more beneficial to welfare than banning them.

Keywords: *alternative housing, animal welfare, cages, laying hens, legislation*

Introduction

Despite extensive consideration of the welfare of laying hens over recent years, there is little specific legislation on how they must be kept, either on a national or an international basis. In the European Community (EC), the most important legal constraint has been the Directive adopted in 1986 and amended in 1988 by the Commission of the European Communities (CEC 1988), which laid down minimum standards for the protection of hens in laying cages. This directive was then translated into national laws; in the UK, for example, the *Welfare of Battery Hens Regulations* were introduced in 1987, requiring new cages to meet these standards by 1988 and all cages by 1995. There is almost no legislation for standards in other systems. However, at about the time of publication of

this article the EC will be drawing up further specifications for the husbandry conditions of hens and this article is concerned with the scientific basis for such specifications.

Although there are few laws which actually dictate how laying hens should be kept if they are not in cages, there has in practice been one other important influence in the EC: the trading standards regulations for labelling of eggs (Table 1). For example, farmers are discouraged from stocking hens on deep litter at more than 7 per m^2, because if they do so they are not legally able to label their eggs as coming from such a system, and it is therefore impossible for them to obtain a premium for their product. Eggs which are sold without one of the four system-labels should be interpreted by the consumer as coming from cages. It must be pointed out, however, that many or most shoppers are not aware of these regulations, and may interpret slogans such as 'Fresh Farm Eggs', which can be legally applied to any category of egg, as indicating that the eggs do not come from cages. However, there are effectively five categories: the four which are named in Table 1, and cages.

Before the adoption of the trading standards regulations, consideration of welfare in different systems was hampered by the fact that there was no restriction on the use of names for different systems and the conditions associated with a particular name changed over time. Thus 'free-range' used to involve small, moveable houses on pasture, but this approach is now almost extinct; systems which can now be called free-range, as in Table 1, used to be called semi-intensive. Indeed, names for systems continue to be invented and adapted. There are also problems in translation between different languages. As one example, the label used on deep litter eggs in The Netherlands ('scharreleieren') and Germany translates into English as 'scratching eggs'; this would be unfamiliar to British shoppers. There is another example in the trading standards regulations themselves: the equivalent of 'perchery' in several languages is not a direct translation (such as 'perchoir' in French) but a translation of 'aviary' ('voliere' in French). However, changes in the use of names have at least been slowed by the regulations, and welfare can be considered within the categories which they define, as in the following section.

Descriptions of the different housing systems mentioned are given in, for example, Kuit *et al* (1989) and in other specific papers cited below.

Welfare in different categories of husbandry system

Welfare has different aspects, as illustrated by the UK Farm Animal Welfare Council's objective that a husbandry system should provide animals with five 'freedoms' (Table 2).

It is evident that problems for laying hens occur in all these aspects and in all the five categories of husbandry system. These problems have been reviewed elsewhere (Wegner 1990a, Appleby 1991, Appleby & Hughes 1991, Mench 1992) and one conclusion is that there are more differences between cages and alternative systems than there are between the individual alternatives.

Table 1 **Criteria defined by EC trading standards regulations for labelling of eggs.**

Label	Criteria
a. Free-range	Hens have continuous daytime access to open-air runs; The ground to which hens have access is mainly covered with vegetation; The maximum stocking density is not greater than 1000 hens per hectare of ground available to the hens or one hen per $10m^2$; The interior of the building must satisfy the conditions specified in (c) or (d).
b. Semi-intensive	Hens have continuous daytime access to open-air runs; The ground to which hens have access is mainly covered with vegetation; The maximum stocking density is not greater than 4000 hens per hectare of ground available to the hens or one hen per $2.5m^2$; The interior of the building must satisfy the conditions specified in (c) or (d).
c. Deep litter	The maximum stocking density is not greater than seven hens per square metre of floor space available to the hens; At least a third of this floor area is covered with a litter material such as straw, wood-shavings, sand or turf; A sufficiently large part of the floor area available to the hens is used for the collection of bird droppings.
d. Perchery (barn)	The maximum stocking density is not greater than 25 hens per square metre of floor space in that part of the building available to the hens; The interior of the building is fitted with perches of a length sufficient to ensure at least 15cm of perch space for each hen.

(CEC 1985)

'Hunger and thirst' are rare, but occasionally occur during induced moulting, which is more commonly practised in cage houses than in other systems. Cages are also likely to compromise all the other four freedoms in Table 2. By contrast, most problems in non-cage systems are associated with freedoms (c) and (e), involving 'pain, injury and disease' or 'fear and distress'. However, these may be worse on occasion in non-cage

systems because of aggression and cannibalism (or preventative beak trimming) associated with large group size. There is one exception to this distinction between cage and non-cage systems: percheries without litter (as allowed by the trading standards regulations) are likely to compromise freedoms (b) and (d) (van Liere 1992). Most published work on percheries has concerned units with partly littered floors (Michie & Wilson 1984, McLean *et al* 1986, Matter & Oester 1989), but since the adoption of the trading standards regulations, commercial percheries have been set up without litter and with high stocking densities (Harrison 1989).

Table 2 **Different aspects of welfare, as illustrated by the UK Farm Animal Welfare Council's 'five freedoms'.**

Freedom	
a. *Freedom from hunger and thirst*	By ready access to fresh water and a diet to maintain full health and vigour
b. *Freedom from discomfort*	By providing an appropriate environment, including shelter and a comfortable resting area
c. *Freedom from pain, injury and disease*	By prevention or rapid diagnosis and treatment
d. *Freedom to express normal behaviour*	By providing sufficient space, proper facilities and company of the animal's own kind
e. *Freedom from fear and distress*	By ensuring conditions and treatment which avoid mental suffering

(Anonymous 1992)

In fact, there have also been criticisms of the stocking densities allowed in the trading standards regulations for the other categories of husbandry systems (free-range, semi-intensive: Appleby *et al* 1992a; deep litter: Harrison 1991). It has been pointed out that commercial alternative systems often have adverse effects on welfare through excessive stocking densities, large flock sizes and lack of adequate or well-sited litter areas (Dun *et al* 1991). However, these are all management mistakes which can be avoided.

The problems with conventional cages[1] are more integral (Table 3) and it is perhaps

[1] The term 'conventional cage' is used here to refer to the laying cage as currently used commercially, providing conditions similar or identical to the minimum standards imposed by the EC Directive (CEC 1988). The alternative term 'battery cage' derives from the fact that cages are usually built in a 'battery' of rows and tiers, which will also be true of other designs of cages.

this which has led to widespread calls, from some welfare groups and concerned members of the public, for cages to be banned. Such calls, though, tend to ignore the fact that cages do have advantages over other systems: they have small group sizes, which restrict the spread of both cannibalism and disease, and they are hygienic, by keeping birds separate from their droppings. This raises the possibility that rather than being banned, cages could be modified to ameliorate their disadvantages to welfare, while retaining these advantages.

Table 3 **Some welfare problems caused by different characteristics of conventional laying cages.**

Characteristics	Welfare problems
Floor entirely of sloping wire	Foot and claw damage
Restricted area	Restriction of movement, causing bone weakness and breakage; restriction of specific behaviour patterns, some causing frustration
Undivided area	Prevention of escape from an aggressor or feather pecker
Restricted height	Frustration of some comfort behaviour
Barren environment, no loose material	Frustration of dustbathing, foraging and pre-laying behaviour; claw damage; feather pecking

(modified from Appleby 1991)

Modified cages

There have been three approaches to the reduction of welfare problems in laying cages: first, the design of conventional cages has been improved; second, designs have been developed to house larger groups of birds, often, but not always, augmented with perches, nestboxes etc; third, novel cages have been designed for conventional group sizes. These approaches will be considered in turn.

Surveys of the incidence of trapping and injury of caged hens (Tauson 1985) have led in recent years to improvements in design and reduction in incidence of these problems (Tauson 1988). Tauson also developed an abrasive strip which, when attached to the egg guard behind the food trough, prevents overgrowth of claws (Tauson 1986); this will be mandatory in cages in Sweden from 1994 (until cages are banned there in 1999). Other recent changes have come from improvements in technology and use of materials: simplified cage fronts with horizontal bars encourage the tendency of birds to feed at the same time (Sherwin 1992), allow easier movement along the food trough and reduce feather wear during feeding (Elson 1988). Solid cage sides also reduce feather damage (Tauson 1989). However, these changes clearly do not address most of the problems in Table 3.

Unaugmented 'colony cages', for larger groups of birds, are now rare but a recent study assessed a new version housing 20 hens with a litter floor, nest boxes and solid, transparent sides (King & Dun 1984). Modern colony cages are also being developed in Switzerland, where conventional cages have been banned since the beginning of 1992 but cages for 40 birds or more are allowed (Matter & Oester 1989). The modified cage which has received most attention, however, has been the get-away cage (Elson 1981, Wegner 1981). This incorporates perches and nest boxes and a greater freedom of movement vertically as well as horizontally, for groups of up to about 60 birds. Early versions had a flat floor and littered nests, but floor laying and dustbathing in nests were problems, and sloping floors and rollaway nests (without litter, allowing eggs to roll away) have supervened (Wegner 1990b). Unfortunately, the increase in group size compared to conventional cages has meant that aggression, feather pecking and cannibalism have sometimes been severe. In addition, there are hygiene problems because birds sometimes defecate on each other. In all these large cages, inspection and catching of birds are also more difficult than in conventional cages.

The simplest modification to the conventional cage design is the shallow or reverse cage, in which the usual narrow/deep dimensions of cages are reversed. This allows all birds to feed simultaneously (Hughes 1983). Another simple change is addition of a perch; this has actually been put into practice in one commercial unit (Rockcliffe 1991). In shallow cages, it is possible to fit a perch across the width of the cage long enough for all birds to perch at the same time. Perches encourage normal roosting behaviour (Tauson 1984) and depending on design may also reduce foot problems and bone weakness (Hughes & Appleby 1989, Duncan *et al* 1992). However, there is some indication that they may cause deformation of the sternum, perhaps from pressure on the sternum during roosting combined with osteoporosis (Appleby *et al* in press), although implications of this for welfare are not known. Perches in cages also cause a production problem: they tend to increase the number of eggs which are cracked or dirty (Tauson 1984). The perches have to be high enough for eggs to roll underneath; hens lay from them perhaps because they prefer a level perch to the sloping floor as a nest site (Duncan *et al* 1992). One solution proposed was to have cages with moveable perches, which were raised above floor level at night but flush with the floor in the day (Luescher *et al* 1982). An alternative which also allows more normal nesting behaviour is to fit nest boxes to cages (Appleby 1990, Appleby & Smith 1991, Sherwin 1992). This is consistent with the idea of an integrated approach to modifying cages so as to ameliorate most or all of the problems in Table 3 - an idea which is now well-established (Robertson *et al* 1989, Nicol & Dawkins 1990). An example of such an integrated approach is given in the next section.

The Edinburgh project on modified cages

The Edinburgh project started with a pilot trial which compared five prototype cage designs with conventional controls (Robertson *et al* 1989). These designs all included perches and nest boxes; some also had dust baths and one had a floor of cushioned slats.

Group size varied from three to 10 birds per cage, with from 450 to 917cm^2 per bird. There were some production problems, particularly with cracked, broken and dirty eggs, but it was concluded that these could be overcome by further modifications to the designs. Physical measurements relevant to welfare - feather, foot and claw condition - and freedom of behaviour were generally improved relative to controls, and more so in some prototypes than in others.

A series of trials then examined facilities separately, to consider their use by the birds and their effects. These all used cages containing four ISA Brown hens.

Trials with perches (Appleby *et al* 1992b, Duncan *et al* 1992) suggest that a perch should be long enough for all birds to use it simultaneously: otherwise the same individuals are excluded repeatedly, particularly at night. A cage width and perch length of 140mm per bird is sufficient because birds can just step on to the perch (Appleby unpublished data); more space is needed for flying or jumping to a perch. A softwood perch of rectangular cross-section (depth greater than height) gives a good grip for the feet, although there would be other possibilities such as textured plastic. The perch should be fitted in the middle of the cage, allowing birds to stand in front of it to feed and also walk behind it so that faeces are trodden through the floor rather than accumulating. This arrangement is not practical with a floor area of only 450cm^2 per bird; for this reason and because of the other arguments for increased space allowance (Table 3), subsequent trials provided 675cm^2 per bird. For adequate clearance above the perch and to allow comfort behaviour such as stretching, cages also have to be higher than conventional; a minimum of 450mm at the back has been found necessary.

For normal nesting behaviour, relatively undisturbed by other birds, a nest site additional to the main cage area is necessary (Appleby 1990). Best results are achieved with a single nest box large enough for at least two birds to nest simultaneously (Appleby & Smith 1991). While it may be possible to provide littered nest boxes with automatic egg collection, consistent use of nest boxes and normal nesting behaviour have been recorded with rollaway nests lined with artificial turf (Appleby *et al* in press).

Dust baths containing sand have also been used consistently by hens, although not for as great a proportion of the time as the litter in a floor housing system (Appleby *et al* 1989), and in addition to their behavioural benefits they also improve foot and claw condition (Smith *et al* in press). If they are provided in the absence of nest boxes birds will use them for nesting (Smith *et al* 1990) and laying in dust baths is also a problem if there are rollaway nest boxes and access to dust baths is unrestricted during the laying period. However, doors are needed on both nest boxes and dust baths to prevent them being fouled, particularly at night (Appleby & Smith 1991, Appleby *et al* in press). In later trials, doors were designed so that they could be used to prevent entrance to dust baths during the main laying period in the morning while allowing pecking at the sand from outside the dust bath at any time. Birds also enter in the afternoon in order to forage by pecking and scratching. The design allows a bird which is in a nest box or dust bath to leave without difficulty when the door closes.

Current trials demonstrate that these possibilities can be combined in practical designs for groups of four or five birds, with few production problems and with benefits for welfare compared to conventional cages (Appleby *et al* in press).

Public attitudes

During the pilot trial of the Edinburgh project, video film of the occupied cages and of other systems was shown to three groups of people - agriculturalists, general public and welfarists - in a study of attitudes to commercial methods of egg production. There was a general preference for less intensive systems and modified cages were perceived as only slightly more acceptable than conventional cages to all three groups (Rogers *et al* 1989). However, this may partly have been caused by the use of film rather than direct observation: wire cage-fronts are very intrusive in photographs. It seems likely that with the more recent improved designs and with proper presentation of appropriate information such as that in this paper, modified cages would be perceived more positively.

In fact, dissemination of scientifically-based information to the public is increasingly relevant in many areas concerned with animal welfare (Appleby & Hughes in press). Where public attitudes influence developments in agriculture which affect welfare, it is important to try and ensure that they do so in an informed and balanced way. With regard to poultry housing systems, such an influence has been most clearly exerted in Switzerland, where the ban on cages was the result of a referendum. It is unlikely that the Swiss public was fully aware of the implications of this ban for either bird welfare or economics of production.

It is also clear that for modified cages to be accepted as an adequate approach to the concerns of those who have called for the banning of cages, there must be consultation and involvement of representative welfare groups in their development and adoption.

Economics

Economic assessment of different systems involves comparison of both expenditure and income. On the income side, some systems currently have an advantage because eggs can be sold at a premium price. The availability of premiums, though, varies between countries and over time: in The Netherlands and Germany they are mostly available for 'scratching eggs' ('scharreleieren' in Dutch) while in the UK they are only common for free-range eggs, and this market is currently declining. An even more important advantage exists where buyers, for example certain supermarket chains in The Netherlands and the UK, will not take any cage eggs at all.

It might be thought that modified cages (including get-away cages) could meet the criteria for percheries in Table 1; however, the definition of perches used by inspectors at least in the UK requires that they are high enough for birds to walk beneath them, so eggs from modified cages can not be sold as perchery eggs. These eggs are therefore unlikely to receive any consistent sales premium over eggs from conventional cages, although premiums may occasionally be obtained by individual businesses, such as the

farmer in Northumberland, UK, who is currently obtaining a premium for eggs from cages fitted with perches (Rockcliffe 1991). If future legislation restricts the most intensive methods of housing hens, this will reduce the disparity between systems and premiums may become even less widely available, and less reliable as an incentive for the producer.

The costs of production in different systems have been reviewed by Elson (1985) and they have been discussed in more detail elsewhere (Appleby *et al* 1992a). The most important factor is food input, which accounts for about 70 per cent of costs. This is higher in most non-cage systems, but is likely to be comparable in modified cages and conventional cages: a potential increase due to increased feeding space (Hughes 1983) will be offset by a potential decrease due to provision of perches (Braastad 1990). Labour costs may be slightly higher. Capital costs will be approximately double, because the designs discussed above allow about twice as much space per bird, and since capital costs are four to five per cent of the total this suggests that overall costs will increase to between 105 and 110 per cent of those in conventional cages. This compares with 105 to 108 per cent in percheries (at 20 birds per m^2) and 170 per cent in free-range systems (Elson 1985).

We have argued that if society is concerned with the conditions in which animals are kept, society should be willing to contribute to the costs of their upkeep, and that the costs of legislation on animal housing should be met partly by subsidy from public funds (Appleby *et al* 1992a). In the absence of such subsidy, the increased costs outlined would be reflected directly in shop prices. While this is a matter for concern, especially for households on low incomes, it would only partly offset the considerable decline in the real price of eggs which has occurred over many years.

Conclusions for legislation

For cages to be banned, they would have to be defined. It is difficult to imagine how that definition could be framed except along similar lines to Switzerland's legislation, which has made illegal any system for housing birds in groups smaller than 40. With currently available strains of birds and current knowledge of management, such legislation will increase the risk of cannibalism or the practice of beak trimming to prevent it.

An approach which would be more logically based on the evidence about welfare, and therefore more scientific, would be to specify in legislation what facilities should be provided for laying hens. In view of the characteristics and problems of conventional cages summarized in Table 3, such legislation should require that hens be provided with more space and height than currently provided, and with alternative substrates such as perches, loose material and nest sites. This approach would, in fact, be consistent with a growing feeling among those involved in animal welfare legislation that there should be a movement away from negative laws towards positive laws (Everton 1989): that legislation should be prescriptive rather than proscriptive. However, some negative laws will continue to be necessary. In the present context, if changes in legislation lead to the disappearance of differential prices between systems, as suggested above, the controlling

influence of trading standards regulations on how hens are kept will also end. In this case, it will be necessary to limit the problems occurring in non-cage laying systems by, for example, specifying maximum permissible group sizes and stocking densities.

Under legislation which specified necessary facilities, decisions on whether to modify cages or to adopt more radical alternatives would be left to producers. The main criterion for those decisions would therefore be economic, and it is likely that this would favour modified cages over non-cage systems.

Animal welfare implications

The welfare implications of a decision on whether laying cages should be banned or modified consist essentially of a comparison of welfare in modified cages with that in alternative systems such as those in Table 1.

The Edinburgh project on modified cages, described above, has alleviated the problems outlined in Table 3, with one partial exception. With the modifications described, birds have considerable local freedom of movement but clearly they do not have freedom to carry out large-scale locomotion. It remains to be determined whether this behaviour is actually important for welfare: no evidence of frustration is apparent, but research on the motivation of hens for locomotion is obviously required. Restriction of locomotion does have physical effects. Bone strengths are increased in non-cage systems compared to cages (McLean *et al* 1986, Knowles & Broom 1990, Nørgaard-Nielsen 1990), and while provision of a perch in cages increased tibial strength in one trial (Hughes & Appleby 1989) and increased tibial mass in another (Hughes *et al* in press) it does not do so consistently (Appleby *et al* in press). While skeletal weakness is not in itself a welfare problem, it is one factor which contributes to the problem of bone breakage, increasing the proportion of birds which suffer breakages during removal and transport for slaughter (Gregory & Wilkins 1989, Gregory *et al* 1990). One response to this must certainly be to consider adoption of non-cage housing systems, but an alternative or complementary response is to develop better handling techniques. In fact, the bones of fewer birds are broken while the birds are housed in cages rather than in percheries (Gregory *et al* 1990). Similarly, as indicated above, it is not known whether depressions in the sternum, which probably also reflect osteoporosis, are harmful to the birds, although further work on this is needed.

These potential disadvantages of cages, which remain despite the modifications, must be offset against their advantages: small group size and hygiene. The most important effect here is on cannibalism, which is uncommon in the small group sizes usual in conventional cages and which are recommended here in modified cages. In the Edinburgh project, no cases of cannibalism have occurred in any of the numerous trials with non-beak-trimmed birds (and feather pecking is also much less common than in conventional cages; Smith *et al* in press). When such birds are housed in floor systems, cannibalism is unpredictable but occasionally very severe, and used to be an important cause of mortality (Schaible *et al* 1947, Kull 1948). Nowadays it is largely controlled by beak trimming, but there is increasing evidence that this procedure causes both

short-term and long-term pain (Gentle 1986, 1992). In the UK it is now recommended that beak trimming should only be carried out as a last resort (MAFF 1987), but this would be impractical in a large flock. The risk of cannibalism and the effects of preventative beak trimming continue to be the most important problems in non-cage systems of management and must be considered against their benefits of increased space and more varied environments.

Despite the remaining questions on freedom of locomotion and its physical effects, welfare of hens in modified cages is appreciably improved compared to that of hens in conventional cages. In retaining the advantages of small group size and hygiene, welfare at the present state of knowledge may also be more reliably improved than in more radical alternatives such as extensive and floor-housed systems. The conclusion of this article is that in the current state of development of alternative systems, legislation which required cages for laying hens to be modified but did not actually ban them would on balance be most beneficial to the welfare of the birds concerned.

Acknowledgements

The Edinburgh project on modified cages was carried out on Contracts 894 and 1557 from the UK Ministry of Agriculture, Fisheries and Food.

References

Anonymous 1992 FAWC updates the five freedoms. *Veterinary Record 131:* 357

Appleby M C 1990 Behaviour of laying hens in cages with nest sites. *British Poultry Science 31:* 71-80

Appleby M C 1991 *Do Hens Suffer in Battery Cages? A Review of the Scientific Evidence.* The Athene Trust: Petersfield

Appleby M C and Hughes B O 1991 Welfare of laying hens in cages and alternative systems: environmental, physical and behavioural aspects. *World's Poultry Science Journal 47:* 109-128

Appleby M C and Hughes B O (in press) The future of applied ethology. *Applied Animal Behaviour Science*

Appleby M C and Smith S F 1991 Design of nest boxes for laying cages. *British Poultry Science 32:* 667-678

Appleby M C, Hughes B O and Elson H A 1992a *Poultry Production Systems: Behaviour, Management and Welfare.* CAB International: Oxfordshire

Appleby M C, Hughes B O and Hogarth G S 1989 Behaviour of laying hens in a deep litter house. *British Poultry Science 30:* 545-553

Appleby M C, Smith S F and Hughes B O 1992b Individual perching behaviour of laying hens and its effects in cages. *British Poultry Science 33:* 227-238

Appleby M C, Smith S F and Hughes B O (in press) Nesting, dust bathing and perching by laying hens in cages: effects of design on behaviour and welfare. *British Poultry Science*

Braastad B O 1990 Effects on behaviour and plumage of a key-stimuli floor and a perch in triple cages for laying hens. *Applied Animal Behaviour Science 27:* 127-139

CEC (Commission of the European Communities) 1985 Amendment 1943/85 to Regulation 95/69, also amended by 927/69 and 2502/71. *Official Journal of the European Communities* 13th July 1985

CEC (Commission of the European Communities) 1988 Council Directive 88/1166/EEC: amendment to 86/113/EEC on Welfare of Battery Hens. *Official Journal of the European Communities* 19th March 1988, L74 p83

Dun P, Hughes B O, Howie T J, Michie W, Shamash E and Wright D 1991 Cages for laying hens. *Farm Buildings Progress Number 106:* 25-27

Duncan E T, Appleby M C and Hughes B O 1992 Effect of perches in laying cages on welfare and production of hens. *British Poultry Science 33:* 25-35

Elson H A 1981 Modified cages for layers. In *Alternatives to Intensive Husbandry Systems* pp 47-50. Universities Federation for Animal Welfare: Potters Bar

Elson H A 1985 The economics of poultry welfare. In Wegner R M (ed) *Proceedings of the 2nd European Symposium on Poultry Welfare* pp 244-253. World's Poultry Science Association: Celle

Elson H A 1988 Making the best cage decisions. In *Cages for the Future* pp 70-76. Cambridge Poultry Conference, Agricultural Development and Advisory Service

Everton A 1989 The legal protection of farm livestock: avoidance of 'unnecessary suffering' and the positive promotion of welfare. In Blackman D E, Humphries P N and Todd P (eds) *Animal Welfare and the Law.* Cambridge University Press: Cambridge

Gentle M J 1986 Beak trimming in poultry. *World's Poultry Science Journal 42:* 268-275

Gentle M J 1992 Pain in birds. *Animal Welfare 1:* 235-247

Gregory N G and Wilkins L J 1989 Broken bones in domestic fowl: handling and processing damage in end-of-lay battery hens. *British Poultry Science 30:* 555-562.

Gregory N G, Wilkins L J, Eleperuma S D, Ballantyne A J and Overfield N D 1990 Broken bones in domestic fowls: effects of husbandry system and stunning method in end-of-lay hens. *British Poultry Science 31:* 59-69

Harrison R 1989 Research into action - some concerns. In Faure J M and Mills A D (eds) *Proceedings of the 3rd European Symposium on Poultry Welfare* pp253-255. World's Poultry Science Association: Tours

Harrison R 1991 The myth of the barn egg. *New Scientist 132 (1797):* 40-43

Hughes B O 1983 Conventional and shallow cages: a summary of research from welfare and production aspects. *World's Poultry Science Journal 39:* 218-228

Hughes B O and Appleby M C 1989 Increase in bone strength of spent laying hens housed in modified cages with perches. *Veterinary Record 124:* 483-484

Hughes B O, Wilson S C, Appleby M C and Smith S F (in press) Effect of perches on bone mass and strength in caged laying hens. *Research in Veterinary Science*

King A W M and Dun P 1984 *Personal Communication Regarding Ventilated Litter Floor Colony System for Layers,* cited by Elson 1985

Knowles T G and Broom D M 1990 Limb bone strength and movement in laying hens from different housing systems. *Veterinary Record 126:* 354-356

Kuit A R, Ehlhardt D A and Blokhuis H J (eds) 1989 *Alternative Improved Housing Systems for Poultry.* Commission of the European Communities: Luxembourg

Kull K E 1948 The prevention and treatment of cannibalism and feather eating in fowls. *Proceedings of the 8th World's Poultry Congress* pp 124-125

Luescher U A, Hurnik J F and Pos J 1982 New cage design for laying hens. *Poultry Science 61:* 606-607

McLean K A, Baxter M R and Michie W 1986 A comparison of the welfare of laying hens in battery cages and in a perchery. *Research and Development in Agriculture 3:* 93-98

MAFF (Ministry of Agriculture, Fisheries and Food) 1987 *Codes of Recommendation for the Welfare of Livestock: Domestic Fowls.* Her Majesty's Stationery Office: London

Matter F and Oester H 1989 Hygiene and welfare implications of alternative husbandry systems for laying hens. In Faure J M and Mills A D (eds) *Proceedings of the 3rd European Symposium on Poultry Welfare* pp 201-212. World's Poultry Science Association: Tours

Mench J 1992 The welfare of poultry in modern production systems. *Poultry Science Review 4:* 107-128

Michie W and Wilson C W 1984 The perchery system of housing commercial layers. *World's Poultry Science Journal 40:* 179

Nicol C J and Dawkins M S 1990 Homes fit for hens. *New Scientist 125 (1708):* 46-51

Nørgaard-Nielsen G 1990 Bone strength of laying hens kept in an alternative system, compared with hens in cages and on deep litter. *British Poultry Science 31:* 81-89

Robertson E S, Appleby M C, Hogarth G S and Hughes B O 1989 Modified cages for laying hens: a pilot trial. *Research and Development in Agriculture 6:* 107-114

Rockcliffe J 1991 Northumberland producer introduces perches into the cage. *Poultry Forum October:* 10

Rogers C S, Appleby M C, Keeling L, Robertson E S and Hughes, B O 1989 Assessing public opinion on commercial methods of egg production: a pilot study. *Research and Development in Agriculture 6:* 19-24

Schaible P J, Davidson J A and Bandemer S L 1947 Cannibalism and feather picking in chicks as influenced by certain changes in a specific ration. *Poultry Science 26:* 651-656

Sherwin C M 1992 Design of cages for laying hens and the influences on behaviour and welfare. *Journal of Animal Science 70 (supplement 1):* 172

Smith S F, Appleby M C and Hughes B O 1990 Problem solving by hens: opening doors to reach nest sites. *Applied Animal Behaviour Science 28:* 287-292

Smith S F, Appleby M C and Hughes B O (in press) Nesting and dust bathing by hens in cages: matching and mis-matching between behaviour and environment. *British Poultry Science*

Tauson R 1984 Effects of a perch in conventional cages for laying hens. *Acta Agriculturae Scandinavica 34:* 193-209

Tauson R 1985 Mortality in laying hens caused by differences in cage design. *Acta Agriculturae Scandinavica 35:* 165-174

Tauson R 1986 Avoiding excessive growth of claws in caged laying hens. *Acta Agriculturae Scandinavia 36:* 95-106

Tauson R 1988 Effects of redesign. In *Cages for the Future* pp 42-69. Cambridge Poultry Conference, Agricultural Development and Advisory Service

Tauson R 1989 Cages for laying hens: yesterday and today ... tomorrow? In Faure J M and Mills A D (eds) *Proceedings of the 3rd European Symposium on Poultry Welfare* pp 253-255. World's Poultry Science Association: Tours

van Liere D W 1992 The significance of fowls' bathing in dust. *Animal Welfare 1:* 187-202

Wegner R M 1981 Choice of production systems for egg layers. In Sorensen L Y (ed) *Proceedings of the 1st European Symposium on Poultry Welfare* pp 141-148. World's Poultry Science Association: Copenhagen

Wegner R M 1990a Poultry welfare - problems and research to solve them. *World's Poultry Science Journal 46:* 19-30

Wegner R M 1990b Experience with the get-away cage system. *World's Poultry Science Journal 46:* 41-47