

# **EXHIBIT E**



## Opinion on Osteoporosis and Bone Fractures in Laying Hens

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Enriched cages for laying hens, 2007

The welfare of farmed gamebirds, 2008

Policy instruments for protecting and improving farm animal welfare, 2008

The welfare of the dairy cow, 2009

## **Opinion on Osteoporosis and Bone Fractures in Laying Hens**

### **Scope**

1. To review the implications of osteoporosis and bone fractures for the welfare of laying hens, particularly in light of the forthcoming ban on conventional cages in Great Britain.

### **Background**

#### Extent and nature of the topic

2. Skeletal health is an important aspect of the welfare of laying hens. Fractures are common but are mostly detected, if at all, after slaughter. They are referred to as either 'old' fractures, i.e. those which occurred during the laying period, or 'new' fractures, i.e. those which occurred during depopulation, transport or slaughter.

3. The incidence of fractures is determined mainly by: i) the weakness of bones, including the susceptibility of keel bones to damage before and after ossification; ii) the design of housing systems, including space availability and layout; and iii) handling at depopulation. In one survey of hens from cages at the slaughterhouse stunner over 20 years ago, Gregory and Wilkins<sup>1</sup> reported that 29% had new fractures of one or more bones.

4. Bone weakness in laying hens mainly results from osteoporosis. This is a pathological condition, which is associated with progressive loss of structural bone throughout lay, thereby rendering bones fragile and susceptible to fracture. In severe cases, it can lead to collapse of spinal bone and paralysis.

5. The keel bone (or sternum) is initially made of cartilage but ossifies at about 35 weeks of age. Before ossification, it may become twisted or otherwise deformed. It may be damaged or broken by collision, for example when the hen jumps onto a perch and lands awkwardly.

6. Loss of bone from the skeleton is increased by mobilisation of calcium for egg shell formation and is decreased by load bearing and biomechanical forces. The hen therefore benefits from walking, hopping, wing flapping and other exercise. The incidence of weakened bones and fractures is affected by genetics and strain, nutrition, housing system and methods of depopulation and is exacerbated by the high egg output and persistency of lay of modern hybrid strains.

7. Osteoporosis and consequent bone fracture are believed to be rare in wild birds, including the progenitors of the domestic fowl, and in broilers.

8. A considerable number of laying hens are subjected to pain as a result of bone fractures.

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<sup>1</sup> Broken bones in domestic fowl: handling and processing damage in end-of-lay battery hens. Gregory and Wilkins. British Poultry Science 1989 30: 555-562

#### Welfare concerns and opportunities to improve welfare

9. Osteoporosis and bone fractures were recognised as welfare concerns soon after cages were introduced over 50 years ago, but it was some time before it was established that osteoporosis was related to the restriction of movement and lack of exercise. Osteoporosis is further exacerbated by the great egg output of modern hybrids. In 1930, a hen laid around 115 eggs in a laying cycle (from about 20 to 72 weeks of age) but nowadays a hen lays around 300 eggs, almost an egg per day for a year. A hen's need for calcium for eggs exceeds her body reserves by about 30 times.

10. Sexual maturation in the pullet is associated with the development of medullary bone and the cessation of re-modelling of structural (i.e. cortical and cancellous) bone. Medullary bone is a calcium store for egg shell formation – each bird requires about 2.3 g calcium each day for egg production – and is formed at the expense of structural bone. The hen cannot re-model cortical structural bone during lay, which therefore leads to a low density of structural bone, osteoporosis and a propensity to fracture.

11. Bone fracture is acutely and chronically painful in humans. In both chickens and humans, bone marrow and growth plates are innervated and there are nociceptors (pain receptors) in the outer layer of the bone. Acute pain is probably associated with the initial trauma. Chronic pain arises from the increased sensitivity of nociceptors and the inflammation in surrounding tissues. These effects are worse and healing takes longer if the fracture site is mobile during repair. This will be a particular problem when a hen must move to reach food, water and a nest box, especially for those parts of the body, such as the legs, that cannot be held immobile.

12. Although spontaneous fractures may occur in severely weakened bones, the incidence of fractures is greatly increased by trauma. Trauma is caused by collisions with 'furniture' in buildings or by poor handling, particularly at depopulation. Contributory factors include the hen's activity and flightiness, the extent to which it is familiar with humans, and housing design.

13. In terms of eliminating or minimising suffering arising from osteoporosis and bone fracture, the design of husbandry systems affects both whether birds perform sufficient activity for adequate bone strength and the risk of traumatic injuries. Genetics and nutrition can also reduce the extent and impact of osteoporosis. Until these improvements can be realised, the decisions of managers and workers determining husbandry and handling practices, especially at depopulation, are particularly important to reduce the frequency of bone fractures.

#### Number of animals involved, duration and extent of poor welfare

14. About 30 million laying hens per year are kept in the UK in a variety of husbandry systems. In terms of egg output, the most common system in 2009 was the conventional cage<sup>2</sup> (46%), followed by free range (37%) and enriched cages (9%) with barn and organic free range systems accounting for about 4% each.

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<sup>2</sup> Conventional cages will be banned in the UK from 2012.

15. It is estimated that about 30% of the total mortality of hens in cages (~4%) is linked to osteoporosis, but that the proportion is much lower in hens in non-cage systems, which have a higher total mortality of ~8%. Thus the number of hens whose death is linked to osteoporosis is about one quarter of a million per year in the UK. This estimate excludes mortality during depopulation and transport to the slaughterhouse.

16. The extent of mortality alone indicates significantly poor welfare for many laying hens.

17. Reliable estimates of the morbidity due to osteoporosis and/or bone fractures are not available systematically.

#### Legal context, including current and imminent legislation and regulations

18. The Animal Welfare Act 2006 (and the Animal Health and Welfare (Scotland) Act 2006) seeks to prevent harm to kept animals through the prevention of unnecessary suffering. It also seeks to promote the welfare of animals by an implied duty of care on those responsible for animals.

19. The Welfare of Farmed Animals (England) Regulations 2007 (and similar regulations in Scotland and Wales) place detailed requirements on keepers of laying hens. For example, on the basis of their genotype or phenotype, animals must be kept without detrimental effects on their health or welfare. For laying hens, which are susceptible to osteoporosis and consequent bone fractures, this gives legal force for the need to exercise and avoidance of trauma.

20. The Welfare of Animals (Transport) (England) Order 2006 (and similar regulations in Scotland and Wales) requires that birds must be fit for a journey. Hens should also be fit to be depopulated. This raises the question as to whether hens with recent or new fractures should be transported at all. FAWC has recently recommended that more consideration should be given to killing end-of-lay hens on the farm<sup>3</sup>.

21. As from 1<sup>st</sup> January 2012, laying hens may not be kept in conventional cages in the European Union, and thereafter only enriched cages or non-cage systems will be permitted.

22. There are also detailed EU requirements for marketing poultry meat. Commission Regulation (EC) No. 543/2008 requires that meat from birds in which the tip of the sternum is rigid (ossified) must be marketed as from a cock, hen, casserole or boiling fowl. This includes end-of-lay hens.

#### National and international considerations

23. Up to 40% of the EU free range flock is located in the UK. After the ban on conventional cages in 2012, the British Egg Industry Council estimates that nearly all laying hens in the UK will be kept either in enriched cages or on free range, with only a few in barn systems.

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<sup>3</sup> Farm Animal Welfare Council. 2009. Report on Welfare of Farmed Animals at Slaughter or Killing – Part Two: White Meat Animals.

24. There are significant concerns about the supply of eggs after the ban on conventional cages. It is conceivable that many imported eggs and egg products will originate from conventional cages that will have been recently banned within the EU.

#### Commercial interests and developments

25. We were told that the British egg industry is limited in its ability to address the physiological causes and consequences of osteoporosis through genetics. This is because the main breeding companies are not based in the UK and determine their breeding programmes by international demands. This argument has some merit but is unsatisfactory because the ban on conventional cages will be introduced throughout the EU, which altogether has a flock of over 300 million hens.

26. However, based upon the extent of the problem, the British industry has expressed its keenness to assist with research and development to reduce the impact of osteoporosis and bone fractures. It sees resolution through genetics, nutrition and housing.

27. Although the market for meat from end-of-lay hens is small, reducing the incidence of bone fractures would also have commercial benefits by reducing bone splinters in the meat.

#### Advice by FAWC and EFSA

28. FAWC has advised Government several times over the past 20 years in various Reports and Opinions that bone fractures are a significant cause of poor welfare in laying hens, most recently in its Opinion on enriched cages for laying hens<sup>4</sup>. We are pleased that Government has responded by funding research on the aetiology, pathogenesis and prevention of osteoporosis and bone fractures in laying hens.

29. This research has shown the benefits of husbandry, e.g. nutrition and design of conventional and enriched cages, and that much suffering can occur at depopulation and while the hens are shackled (live) at the abattoir. The Government has also advised farmers and abattoir workers about the welfare risks due to osteoporosis in laying hens.

30. In 2004, EFSA published its advice on the welfare of laying hens in different systems<sup>5</sup>. It recommended further research into the detection of bone fractures, the prevalence of the problem across the EU and the causes of fractures. It also recommended that husbandry systems should provide sufficient space for exercise to maintain bone strength and minimise the risk of fractures.

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<sup>4</sup> Farm Animal Welfare Council. 2007. Opinion on enriched cages for laying hens.

<sup>5</sup> European Food Safety Authority (EFSA). The welfare aspects of various systems of keeping laying hens. [http://www.efsa.europa.eu/EFSA/efsa\\_locale-1178620753812\\_1178620775132.htm](http://www.efsa.europa.eu/EFSA/efsa_locale-1178620753812_1178620775132.htm)

## Evidence

### Bone fractures

31. In the 1980s and 90s, scientists at the University of Bristol carried out full dissections to detect bone breakages in end-of-lay hens arriving at the abattoir. In one study<sup>6</sup>, the prevalence of bone fractures in 3,115 hens was measured.

<u>System</u>	<u>Old fractures %</u>	<u>New fractures %</u>
Conventional cage	5	31
Perchery	25	10
Free range	12	14

32. While some new bone fractures in hens from cages occurred when the hens were hung on the shackles at the abattoir, the majority occurred at depopulation and were probably related to handling and cage design. The new fractures included about 8% of hens with broken wings. More careful handling of the hens during removal from the cages reduced the prevalence of new bone fractures from 31% to 14%. In birds from non-cage systems, old bone fractures (especially of the keel bone and furculum) were more common and were probably caused by collisions with the building's furniture.

33. A more recent study of 18 flocks in 2006 (Scottish Agricultural College; Defra project AW0231) showed that old fractures, mainly of the keel bone, were more common in hens from free range and barn systems than those in cages, while new fractures, mainly of the wing, were less prevalent in hens from enriched cages than those in conventional cages. In conventional cages 17% of hens had new wing fractures, which was double the prevalence of 8% found in 1990. The overall prevalence of fractures in all bones was disturbingly high.

<u>System</u>	<u>Old fractures %</u>	<u>New fractures %</u>
Conventional cage	23	24
Enriched cage	27	6
Barn	42	10
Free range	44	10

34. The most recent results (University of Bristol; Defra project AW0234), from a survey of 67 flocks (not including conventional cages) were similar but even worse, particularly because only keel bone fractures were recorded. Thirty six per cent of hens from enriched cages had fractures (of the keel bone) and the average prevalence in other non-cage systems ranged from 45 to 86%. In the worst flocks, 95% of hens had fractured keel bones. A contributing factor was provision of perches, many of which were not well-designed.

35. While systematic data are not available and factors such as housing are not constant, this and other evidence suggest that the prevalence of bone fractures in laying hens has not declined over the past two decades, may be rising and is much higher than is acceptable.

<sup>6</sup> Broken bones in domestic fowls: effect of husbandry system and stunning method in end of lay hens. NG Gregory et al. British Poultry Science (1990) 31: 59-69



### Bone strength

36. Numerous studies have compared bone density or strength (usually by breaking bones on a three-point rig) *post mortem* in hens from different housing systems.

37. We were told that work at the Roslin Institute in 2004 showed a stronger tibia and humerus in hens kept in floor systems or percheries compared with hens in cages. Adding a perch to conventional cages increased tibia strength by between 13 and 19%<sup>7</sup>. Another study<sup>8</sup> found greater humeral strength in hens kept in enriched than conventional cages, suggesting that wing flapping exercise is important, though there was no effect of enrichment on tibia strength.

38. Assessment of fractures *in vivo* is difficult but palpation of the keel bone by experienced assessors appears to provide a meaningful assessment of old fractures<sup>9</sup>. The results correlated well with those of full dissection and inspection of the skeleton in hens from free range and barn systems.

39. Drawing together much of this work led to the formulation of a bone index<sup>10</sup>, which combines measurements of radiographic density of the keel bone, strength of the humerus and tibia, and body weight. There is a good correlation between characteristics of different bones, suggesting that assessment of a single bone in the skeleton could be used to gauge overall skeletal strength. Furthermore, *in vivo* assessment of the keel bone may be possible using a digitised fluoroscope.

40. The index has been used to select hens for bone strength; the incidence of fractures was significantly decreased in a line selected for high bone strength. This appeared to be mediated by improved cortical bone width during rearing and slower resorption of bone during lay. Humerus fracture incidence differed by a factor of 6 between the lines in the 6<sup>th</sup> generation of selection. Another study<sup>11</sup>, using a similar selection method, found improvements of 14% in keel bone density, 22% in humeral strength and 37% in tibiotarsal strength after six generations in high versus low bone index strains. Selection for bone strength could be a long term strategy for alleviating some of the problems associated with osteoporosis. Studies of the potential of genetic selection for increased bone strength also suggest that there are no adverse effects on egg production or eggshell strength: indeed there may even be benefits.

41. Genetic research has now turned to more targeted selection methods, including use of quantitative trait loci (QTLs) for marker assisted selection. The first significant QTL related to bone quality in poultry has been reported<sup>12</sup>. The development of whole genome selection is even more promising and involves analysis of many markers throughout the genome for correlation with the trait of interest, in this case bone strength.

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<sup>7</sup> Increase in bone strength of spent laying hens housed in modified cages with perches. Hughes and Appleby. Veterinary Record 124, 483-484 1989

<sup>8</sup> Keeping Laying hens in furnished cages and aviary housing system enhances their bone stability – M Leyendecker et al, British Poultry Science Vol 46, No 5 (October 2005) pp 536-544

<sup>9</sup> Investigation of palpation as a method for determining the prevalence of keel and furculum damage in laying hens. Wilkins et al. Vet Record Oct 30, 547-549 2004

<sup>10</sup> Inheritance of bone characteristics affecting osteoporosis in laying hens. Bishop et al. British Poultry Science 41, 33-40 2000

<sup>11</sup> Differences in composition of avian bone collagen following genetic selection for resistance to osteoporosis. Sparke et al. British Poultry Science 43, 127-134 2002

<sup>12</sup> QTL for osteoporosis in f2 population White leghorn chicken lines selected for bone index. IC Dunn et al. Animal Genetics 38: 45-49 2007

### Nutrition

42. Inclusion of appropriate amounts of calcium in diets and attention to other complex nutrient requirements has reduced the worst problems seen several decades ago, including spinal collapse (euphemistically called 'cage layer fatigue'). Nutrition has the potential to reduce bone problems further.

43. Feeding calcium as particles rather than finely ground mash extends the period of calcium absorption into the night when shell formation takes place. This appears to improve medullary bone without much impact on the loss of structural bone<sup>13</sup>. Work at the Roslin Institute (Defra project AW1120) has demonstrated that dietary combinations of calcium and fluoride can increase bone strength by ~20%. Other components of the diet such as phosphorus and omega-3 are also under consideration.

44. Genetic, dietary and other environmental improvements in bone quality are independent and additive<sup>14</sup>.

### Handling

45. Until or unless breeding can produce hens with less fragile bones, suitable diet and housing design and careful handling will be the main preventative approaches. When removing hens from cages, new fractures are reduced by large cage doors and a support slide over the feed trough. Catching birds in enriched cages and non-cage systems is difficult and can also cause new fractures<sup>15</sup>. In conventional cages, catching birds by one leg resulted in a prevalence of new fractures of 11 to 14% but removing them by two legs reduced this to 5%<sup>16</sup>.

46. The Joint Industry Welfare Guide to the Handling of End of Lay Hens and Breeders<sup>17</sup> gives helpful advice but may need updating in view of the ban on conventional cages and ongoing development of other systems.

### Evidence from farming and allied industries

47. The UK egg industry is aware of the problems caused by osteoporosis in laying hens and is actively pursuing solutions based on genetics, nutrition and management.

48. There has been some progress on the nutrition of pullets during rearing, including the use of minerals and enzymes (to help their absorption), but providing the optimum particle size of calcium is difficult because of current methods of feed handling. Blowing feed into bulk bins can separate larger particles from the rest of the feed. Adjustment of nutrition as the hens age is also critical in preventing osteoporosis.

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<sup>13</sup> Bone structure and strength at different ages in laying hens and effects of dietary particulate limestone, vitamin K and ascorbic acid. Fleming et al. *British Poultry Science* 39: 434-440 1998

<sup>14</sup> Relationships between genetic, environmental and nutritional factors influencing osteoporosis in laying hens – RH Fleming et al, *British Poultry Science* 47 (6) 742-755 2006

<sup>15</sup> The welfare effects of different methods of depopulation on laying hens. Defra project AW0231, 2006

<sup>16</sup> Effect of catching method and lighting intensity on the prevalence of broken bones and on the ease of handling of end-of-lay hens. Gregory et al. *Veterinary Record* 132, 127-129 1993

<sup>17</sup> Available from British Egg Industry Council, 2nd Floor, 89 Charterhouse Street, London EC1M 6HR

49. Perch usage has improved in both rearing and laying systems (apart from conventional cages). The industry suggests that this leads to improvements in structural bones due to exercise.

50. The breeders state that they select against osteoporosis and there is a positive correlation with egg shell quality. However, progress is limited by the lack of practical methods to measure bone strength *in vivo*. Breeders are also well aware of whole genome selection and suggest this may become practical in the near future.

#### Other pertinent information

51. The price of end-of-lay hens at depopulation is low, mainly because the meat has little value. If the price were higher, more attention may be given to preventing injury in such animals, with corresponding benefits for their welfare.

52. Little if any information about the prevalence of fracture bones in end-of-lay hens is collected at the abattoir. Some abattoirs for broilers have systems for automatic detection of broken legs, allowing the birds to be processed separately.

53. European Council Directive 99/74/EC requires that hens are provided with perches. The European Commission and the Scottish Government interpret this requirement as aerial perches (high enough for hens to walk underneath) but Defra considers that the need is met by perches within slatted floors. Hens are motivated to roost on raised perches and their use may increase bone strength.

54. Deformation of the keel bone may result from hens sitting on perches, particularly before ossification, while collisions with perches may break keel and other bones. Both problems are affected by the design and arrangement of perches. The devolved administrations in Scotland and Northern Ireland advise that perches should be ~4 cm wide with no sharp corners, spaced 30 cm horizontally and vertically, giving an angle of about 45° for jumping up or down. Perches should be provided at feeders and drinkers and over slats, minimising clutter and emphasising ease of access for both hens and humans. A commercial-scale trial of barn systems has found no difference in keel bone damage in hens with perches arranged as above and those without.

#### Areas of incomplete evidence, including irresolvable or disputed issues

55. Deformation of the keel bone may be reversible. There is no information on other factors affecting deformation, such as the cartilage's characteristics before ossification and the timing and nature of ossification, or the way in which such factors are affected by genetics, diet and other aspects of the environment. Nor is it known whether keel bone deformation (before ossification) is painful or in any other way a welfare problem. Research is under way on this (Defra sponsored project AW1142).

56. Little is known about the incidence or detailed nature of osteoporosis in commercial conditions except through the occurrence of bone fractures (which are also affected by other factors and often pass undetected). For example, studies of bone strength generally emphasise averages rather than variation between individuals. It is not known whether, in the absence of fractures, osteoporosis causes any welfare problems.

### **Critical issues**

57. There is good evidence that the prevalence of bone fractures in laying hens is not declining and may actually be rising. More needs to be done to reduce this significant cause of poor welfare. This need is acute in view of the forthcoming ban on conventional cages, which will reduce some causes of bone fracture (particularly osteoporosis) but increase others (particularly collisions in some housing designs).

58. Selection for high egg production, combined with rearing methods including control of light periods, has produced hens that are very vulnerable to bone fractures. It is questionable whether it is possible to maintain egg output of around 300 eggs in the laying cycle while attaining bone strength sufficient to reduce this vulnerability.

### **Ethical analysis**

59. Some have attempted to balance the adverse welfare due to bone fractures acquired at the end of lay against the chronic injuries requiring extensive and prolonged repair during egg production.

60. Bone fractures severely compromise at least four of the Five Freedoms, i.e. freedom from discomfort; freedom from pain, injury and disease; freedom to perform normal behaviour and freedom from fear and distress. Fractures during the laying period may also reduce the animal's ability to reach feed and water and so also compromise its freedom from hunger and thirst.

61. In relation to their quality of life, hens with fractured bones certainly do not have a good life. Some fractures, for example in the limb bones, may take a considerable time to heal, or may never heal properly, and meanwhile cause considerable pain and obstruct the hen in reaching feeders and drinkers and carrying out other maintenance activities. A hen with such a fracture is unlikely to have a life worth living<sup>18</sup> and should be culled humanely and swiftly.

62. While some hens continue to lay eggs despite bone fractures, others cease to lay or do so less efficiently. It is therefore in the farmer's interests, as well as the hen's, to reduce or prevent this problem. Reduction in fractures during depopulation, transport and killing would also benefit processors by reducing bone fragments in the meat.

### **Conclusions**

63. A direct result of selection and management of laying hens for egg production and intensive rearing is a steady fall in the real price of eggs, but laying hens suffer because of bone fractures.

64. The incidence of bone fractures of laying hens, both during and at the end of lay, is too high in all systems of husbandry. Breeding selection and production system management can reduce this problem considerably and perhaps eliminate it, which is the ideal.

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<sup>18</sup> Farm Animal Welfare Council. 2009. Report on farm animal welfare in Great Britain: past, present and future.

65. The design and management of systems of egg production must legally be such as to reduce and if possible prevent bone fractures. Poultry houses can be improved by attention to the design and layout of non-cage systems and of cage openings in enriched cages. Hens should be handled at depopulation in all systems with great consideration for their fragility and welfare.

66. Provision of raised perches in non-cage systems sometimes increases the prevalence of fractures, particularly of the keel bone, but there are other benefits for welfare. The design and layout of perches can be improved to prevent bone fracture. If this is achieved, the different interpretations of the relevant European Directive within Great Britain could be eliminated, favouring provision of aerial perches.

67. It is difficult to feed calcium in large particles to laying hens. New methods are needed to benefit bone strength.

68. It is not feasible at present to identify all hens on farm with fractures. Nevertheless if hens with fractured bones are detected, they should be treated or culled. Practical techniques and criteria for intervention for use on farm should be developed for public or private surveillance (and should be adopted by assurance schemes among others). Though surveillance might be difficult during the laying period, chronic pain could be prevented by appropriate action. Detection of hens with fractured bones prior to transport would help to ensure that they are excluded as not fit to be transported.

69. Detection of bone fractures at the abattoir is feasible, using palpation for some breaks and automatic methods for others, and could be used to quantify the extent of the problem in particular flocks and to identify and reduce the causes. It would also allow carcasses with newly broken bones to be identified, reducing the number of bone fragments and increasing the value of the meat.

70. If restrictions on describing meat from end-of-lay hens as chicken could be modified, this might increase its value and encourage better care of end-of-lay hens prior to and during killing.

71. Killing end-of-lay hens in their housing would avoid the problems of bone fractures during depopulation.

72. The economics of implementing all the measures that can reduce or prevent fractures, including breeding, feeding and handling, will of course need careful evaluation but cannot be the sole factor in determining outcomes. For example, methods currently available for killing end-of-lay hens in their farm housing (including carcase disposal) cost more than removal to a slaughterhouse but this current position should not prevent discussions among all stakeholders on how such methods might be adopted.

### **Recommendations**

73. We strongly recommend that the egg industry (including retailers) should aim to eliminate bone fractures in live birds altogether. To that end, it should develop a strategy of time-related reduction with interim targets for the prevalence of fractures both during lay and at depopulation. The first target could be based on what is

currently achieved by the top 10% of producers. As that information is not currently available, we suggest for illustration a possible interim target of less than 20% fractures during lay (i.e. 'old' fractures at slaughter) and 5% at depopulation ('new' fractures), within 5 years of the publication of this Opinion.

74. The industry should carry out surveillance in collaboration with Governments in Great Britain to establish trends in the prevalence of bone fractures in laying hens, identify the efficacy of various preventative measures and assess the impact of the forthcoming ban on conventional cages. The latter assessment should include the relative merits of enriched cages and non-cage systems.

75. Design and management of systems to reduce and if possible prevent bone fractures should be given high priority, including dissemination of this information through the industry. This should include development of intervention strategies to be used during lay, if significant numbers of birds are identified and culled for fractures.

76. Once design and layout of perches have been improved to prevent bone fracture, the different interpretations of legal requirements within Great Britain should be eliminated, favouring provision of aerial perches.

77. Retailers should give similar attention to reduction of fractures in hens in other countries supplying eggs and egg products that they import.

78. Mechanisms should be developed to raise incentives to farmers and handlers for a low prevalence of bone fractures and other injuries in hens, coupled with penalties for a high prevalence.

79. Greater attention should be given by breeders to minimise osteoporosis in laying hens by breeding, e.g. by genetic selection for bone quality. This may require Government activity at international level as the major breeders are based abroad.

80. The results of nutritional research should be applied by the egg industry to improve diets during rearing and lay, particularly to reduce the loss of structural bone. Feeding methods should be developed by industry to allow calcium to be fed in large particles within balanced diets.

81. Research and development should be undertaken by the Government and industry on i) welfare significance of different fractures and of keel bone deformation; ii) evaluation of preventative husbandry measures; iii) detection of fractures in hens on farms and at the abattoir; iv) practical methods for on-farm killing of end-of-lay hens; and v) handling of end-of-lay hens during depopulation.

82. The Government and devolved administrations should discuss with the European authorities the need for a permitted description of meat from end-of-lay hens that is attractive to consumers, to increase the value of these birds and hence to promote better care.

**APPENDIX – Those who provided evidence or assistance**

ADAS

British Egg Industry Council

British Free-range Egg Producers Association

British Poultry Breeders and Hatcheries Association

British Veterinary Poultry Association

Compassion in World Farming

Defra

European Forum of Farm Animal Breeders

National Farmers' Union

National Farmers' Union Scotland

National Farmers' Union Wales

Roslin Institute (Edinburgh)

Royal Society for the Prevention of Cruelty to Animals

Royal Veterinary College

Scottish Agricultural College

Scottish Egg Producers and Retailers Association

Scottish Government Environment and Rural Affairs Department

University of Bristol

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