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The Welfare and Productivity of Hens in a Barn System and Cages

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The welfare and productivity of hens in a barn system and cages

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Foreword

The housing of poultry in cages is a contentious issue and is likely to remain under intense public scrutiny while the industry houses the majority of hens in this system. Thus, there is a need to examine alternatives under Australian conditions.

While there has been a considerable research effort on cage systems, unfortunately there has been considerably less thorough research on non-cage systems, with a major emphasis being the solving of practical problems rather than developing an understanding of some of the principles through a systematic scientific approach. Consequently, there is a dearth of reliable data.

Of the alternative systems available, the barn system (hens housed loose in a naturally ventilated shed with litter, perches and nest boxes) is probably the most easily adopted in Australia. Indeed, there are a few farms currently producing barn eggs in Australia.

This publication takes an experimental approach to compare welfare and production of laying hens in conventional cages and a barn system. It also reports on a workshop to document some of the operational problems and identify possible solutions during the establishment and maintenance of a barn system for laying hens in the Australian environment.

The project is part of RIRDC's Eggs Program which aims to support improved efficiency, sustainability, product quality, education and technology transfer in the Australian egg industry. One of the program's key strategies is to improve bird welfare and bird performance.

Peter Core
Managing Director
Rural Industries Research and Development Corporation

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Contents

Executive Summary

- While there has been a considerable research effort on cage systems for laying hen production, unfortunately, there has been considerably less thorough research on non-cage systems. In relation to the latter, the major emphasis has been solving practical problems rather than developing an understanding of some of the principles through a systematic scientific approach. While this may be understandable because of both the politics of apparent urgency and the expense and time involved in researching non-cage systems, the end result is a dearth of reliable data.
- Nevertheless, while there is a lack of scientific knowledge of non-cage systems as a whole, there is considerable industry experience, particularly with the use of the barn system, which is based on some traditional elements of poultry husbandry.
- Thus, there is a need for replicated experiments on a number of welfare variables in non-cage systems and the experimental component of this project compared the welfare of hens in a barn system and conventional cages in a commercial environment. In addition, to document some of the industry experiences with barn hen production, a workshop was held and some of the problems and solutions are discussed.
- In the experimental part of the project there were 2 treatments:
    - Cage - hens housed in conventional cages (2 birds/cage with a floor area of 1504 cm^2/cage). Twenty four cages were installed in each of 3 compartments and fenced off from the compartment.
    - Barn - hens in 3 compartments of a barn system (900 hens/compartment and 7 birds/m^2).
- There were 4 sampling periods: 3 weeks after introduction when the birds were 20 weeks of age, 12 weeks after introduction at the peak of lay at 29 weeks old, 23 weeks after introduction at mid-lay at 40 weeks old and 47 weeks after introduction at the end of lay at 64 weeks of age, just prior to the shed being de-stocked.
- Welfare was assessed on the basis of the level of stress, immunology, feather condition/cover and bone strength. In addition, production parameters were monitored and egg quality measured.
- Both systems of housing the birds had advantages and disadvantages. The barn hens, in comparison to the caged birds, had a lower body weight, better feather condition and cover until 29 weeks of age, poorer feather condition and cover at 40 and 64 weeks of age, higher levels of stress (based on corticosterone concentrations from a 'spot-sample'), higher immunological responsiveness (based on limited evidence from an *in vitro* test examining the ability of white blood cells to kill bacteria), higher parasite burdens, particularly at 20 weeks of age, poorer egg microbial quality, particularly from the floor eggs, higher bone strength and fewer broken bones, lower egg production and a lower egg colour score, particularly at 20 weeks of age.
- Notwithstanding the above findings, caution is required in interpreting the data since this experiment had a number of constraints imposed by working in a commercial environment and there were a limited number of replicates.
- On the basis of a workshop on barn hen production systems, eleven areas were identified as potential problems or areas for improvement. These were:
    - Lower body weight
    - Lower egg production

- Incidence of floor eggs
- Microbiological quality
- Parasite control
- Guidelines for maximum number of birds per shed
- Guidelines for shed design and equipment options
- Social behaviour of birds and rearing effects
- Beak trimming
- On-farm data recording
- Marketing

- There were a number of recommendations arising from both the experimental work and the workshop. These were:
    - Further comparative experiments of the different laying hen production systems are required before the findings of the present project can be extrapolated to barn production systems in general.
    - Thresholds of body weight for high levels of egg production have been established for cage systems and these have been well researched in Australia. The body weights of flocks in barn systems are frequently below these thresholds and research needs to be undertaken to evaluate these relationships and their interactions with social behaviour in large groups where the energy requirements may be higher, in part due to a change in social behaviour.
    - The lower egg production in the barn system is consistent with the lower body weight and the relationship between body weight management, bird behaviour and egg production needs to be defined.
    - The practical solutions to reduce floor eggs need to be documented and made available to producers interested in establishing non-caged flocks.
    - This report provides some general information on parasite control and this information should be made available to industry.
    - Most of the commercial developments in non-cage systems in Europe are operating with a maximum flock size of 5,000-10,000 hens. At this stage, maximum flock size, in Australia, should be flexible until there is scientific evidence to suggest a stronger stance.
    - Some systematic analysis of rearing management and subsequent behaviour is required for barn hen production. Initial information could be obtained by quantifying different levels of flock aggression in the laying phase.
    - Comments are frequently made of the high level of approach behaviour towards humans in the barn system. Existing methodology (for broilers) should be applied/adapted to survey the behavioural responses of hens in barn systems to humans.
    - There is a need to test the robustness of the early beak trim in well controlled experimentation for barn hens, and to begin to identify other variables that interact with pecking behaviours.
    - Because of the lack of information on barn systems in Australia, on-farm records could provide valuable information. Important data are farm numbers, flock sizes, floor egg incidence, mortalities, cannibalism outbreaks, egg production estimates and estimates of flock body weights.

- Further experimentation comparing production systems is required to determine the general applicability of the findings of the present project to different designs of barn hen production.
- Study factors affecting nesting behaviour that reduce floor eggs.
- Examine egg microbial quality from farms identified with superior nesting performance.
- Determine the impact of social behaviour of birds in large groups on low body weight and egg production.
- Study flock body weights and uniformity in relationship to flock production in barn systems, and relate these data to body weight patterns identified in cage systems.
- Determine if there is an optimum or maximum group size for barn hens from both management and welfare perspectives.

- In conclusion, this project has identified some potential advantages and disadvantages of cage and barn hen systems of laying hen production. While the above data suggest some welfare and production problems associated with barn hen production, it must be emphasized that this experiment examined a single barn hen system and a single cage type. Thus, the constraints this imposed along with the limited number of replicates and the additional constraints of working in a commercial environment, means the findings of this experiment cannot be extrapolated to a generic system of barn hen production. It must also be recognized that since the barn hen sector of the egg industry is in its early stages of development in Australia, there is an expectation that, given additional research and industry experience, both level of production and bird health will be equivalent to that achieved in cage systems. This expectation is based on the results being achieved overseas and local experience. Thus, barn hen production is likely to fill an important niche in the community's requirements for non-cage eggs.

General Introduction

There has been a considerable research effort on cage systems and this has been recently reviewed by Barnett and Newman (1997). Unfortunately, there has been considerably less thorough research on non-cage systems, with a major emphasis being the solving of practical problems rather than developing an understanding of some of the principles through a systematic scientific approach. While this may be understandable because of both the politics of apparent urgency and the expense and time involved in researching non-cage systems, the end result is a dearth of reliable data. With the exception of the studies by Tauson *et al.* (1992) and Abrahamsson and Tauson (1993, 1995), which are replicated experiments, most of the other studies have either minimal or no replication (Methling and Grunwoldt, 1992; Engstrom and Schaller, 1993; Swiss Society for the Protection of Animals 1993; Taylor and Hurnik, 1994) and thus it is difficult to draw rigorous conclusions from them and Elson (1992) recommends considerable caution in using these data. Nevertheless, there is considerable support for these non-cage systems, in part on the basis of the increased behavioural repertoire they permit (Tanaka and Hurnik, 1992; Taylor and Hurnik, 1994) and lower levels of fear in the tonic immobility test (Hansen *et al*., 1993). A number of alternative systems, including details of economics, advantages and disadvantages, are described in Kuit *et al*. (1989).

While there is a lack of scientific knowledge of these systems as a whole, there is considerable industry experience, particularly with the use of the barn system, which is based on some traditional elements of poultry husbandry that were in use prior to the introduction of the battery cage. Also, some of the components of the system have been systematically studied. For example, it is generally agreed that bone strength is improved in non-cage systems (McLean *et al*., 1986; Knowles and Broom, 1990; Norgaard-Nielsen, 1990; Gregory *et al*., 1991), although it has been identified that all systems with perches result in keel bone deformation (Engstrom and Schaller, 1993; Abrahamsson and Tauson, 1995). Other aspects that have been or are being studied are spacing between perches (Scott and Parker, 1994; their data suggest that birds are less successful negotiating distances greater than 1.0 m), space allowances for different behaviours (the frequency of walking and ground pecking were reduced as space allowance decreased; Keeling, 1994) and rearing conditions (low density rearing resulted in less feather pecking prior to the laying phase; Hansen and Braastad, 1994). While it has been shown that hens prefer to congregate with familiar than unfamiliar birds, although the unfamiliar birds become familiar with experience (Bradshaw, 1992), the relevance of this to welfare and housing design is unknown.

While industry statistics on mortalities could be collected, from both overseas and locally, to provide limited information on welfare and additional information on production, floor eggs, egg quality, etc. which may be used to encourage producers to use these alternatives, there is an urgent need for replicated experiments on a number of welfare variables in non-cage systems. The experimental component of this project compares the welfare of hens in a barn system and conventional cages in a commercial environment. Welfare was assessed on the basis of the level of stress, immunology, feather condition/cover and bone strength. In addition, production parameters were monitored and egg quality measured. Furthermore, to in an attempt to document some of the industry experiences with barn hen production, a workshop was held and some of the problems and solutions are discussed.

Objectives

1. To compare welfare and production of laying hens in conventional cages and a barn system.

2. To document operational problems and identify possible solutions during the establishments of a barn system for laying hens in the Australian environment.

THE WELFARE OF BIRDS IN A BARN VERSUS A CAGE PRODUCTION SYSTEM:

Introduction

Previous research on cage modifications has shown that bird welfare could be compromised if overseas recommendations are adopted without local evaluation. For example, while solid sides in cages can improve feather condition/cover, this cage modification (under Australian conditions) can result in reduced welfare, on the basis of increased mortality particularly in hot weather (Barnett *et al*., 1997a; Glatz and Barnett, 1996).

Of the alternative systems available, the barn system (hens housed loose in a naturally ventilated shed with litter, perches and nest boxes) is probably the most easily adopted in Australia, in part because of the lower financial risk compared to some other more sophisticated alternative systems and because of some similarities to traditional 'back-yard' production. Indeed, there are a few farms currently producing barn eggs in Australia. While there is a lack of scientific knowledge of alternative systems as a whole, there is considerable industry experience, particularly with the use of the barn system, which is based on some traditional elements of poultry husbandry that were in use prior to the introduction of the battery cage. Also, some of the components of the system have been systematically studied. For example, it is generally agreed that bone strength is improved in non-cage systems (McLean *et al*., 1986; Knowles and Broom, 1990; Norgaard-Nielsen, 1990; Gregory *et al*., 1991), although it has been identified that all systems with perches result in keel bone deformation (Engstrom and Schaller, 1993; Abrahamsson and Tauson, 1995). Other aspects that have been or are being studied are spacing between perches (Scott and Parker, 1994; their data suggest that birds are less successful negotiating distances greater than 1.0 m), space allowances for different behaviours (the frequency of walking and ground pecking were reduced as space allowance decreased; Keeling, 1994) and rearing conditions (low density rearing results in less feather pecking prior to the laying phase; Hansen and Braastad, 1994). While it has been shown that hens prefer to congregate with familiar than unfamiliar birds, although the unfamiliar birds become familiar with experience (Bradshaw, 1992), the relevance of this to welfare and housing design is unknown.

This project compared the welfare of hens in a barn system and conventional cages in a commercial environment. Welfare was assessed on the basis of the level of stress, immunology, feather condition and cover and bone strength. In addition, production parameters were monitored and egg quality measured. It was originally intended to conduct 6 replicates of the experiment over two time periods (i.e. using 2 flocks over 2+ years). The first three replicates were completed on schedule. However, around the time of commencement of replicates 4-6 the collaborating producer decided to separate his barn hen and cage flocks onto separate sites and thus, following discussions with RIRDC, the project was terminated early. Thus, the following data in relation to objective 1 are based on 3 replicates only and considerable caution is required when discussing the findings of this experiment in relation to barn systems in general.

Materials and Methods

A commercial barn system at a farm approximately 80 km north east of Melbourne was used for the conduct of this project. In the barn system Hisex hens were housed loose within a shed; there was litter (sawdust) on the floor and nest boxes; the birds could perch on the feeder lines and on entry platforms to the nest boxes. The shed was divided into 4 compartments of about 900 hens per compartment. Three compartments were used for this experiment.

There were 2 treatments:

- Cage
- Barn

These 2 treatments were in 3 replicates: i.e. each treatment was represented in 3 of the 4 compartments of the shed. This was to be repeated with a second batch of Hisex hens to give a total of 6 replicates per treatment. However, the producer did not continue the barn system with another batch of birds and hence the project was terminated after 3 replicates. The following details refer to replicates 1-3 which were completed.

Treatment i) Cage - hens housed in conventional cages (2 birds/cage with a space allowance of 1504 cm^2/cage). This space allowance was chosen on the basis of previous research that used similar measures of welfare (Barnett *et al.*, 1997a, 1997b), although it is recognized that the space allowance was more generous than that commonly used in industry. Twenty four cages were installed in each of 3 compartments and fenced off from the compartment. The banks of cages were situated along the walls dividing the compartments. The positions of the 3 banks of cages were randomly assigned to 5 possible sites (an additional site close to the entry to the shed was not available for use). These birds were fed manually and their eggs were collected manually from the roll-out trays.

Treatment ii) Barn - hens in a barn system (900 hens/compartment and 7 birds/m^2) i.e. the remainder of the compartment, not occupied by the cages, was available to the floor housed birds as normal. (Prior to this experiment, birds were previously housed at 1000 birds/compartment). Within each compartment the barn system was separated from the cages by a mesh wall to prevent movement of birds between compartments and between barn and cage birds within compartments.

The birds were reared in cages until placed into the barn shed. From day 1 they were in brooders with a space allowance of 240 cm^2/bird and at 8 weeks were transferred to grower cages with a space allowance of 350 cm^2/bird. Birds were introduced into the shed at 16 weeks and 3 days of age and placed into treatment (i.e. birds were randomly selected from the floor and transferred to cages) 3 days later (17 weeks of age). During week 1 in the barn shed, a coccidiostat was supplied via the drinking water. Different birds were sampled at each of the 4 sampling periods and to prevent the same birds being sampled, the birds sampled were identified with leg bands. The farm was visited every fortnight by research staff to maintain the cooperation of the producer and the staff involved in maintaining the shed.
The experiment commenced in September (spring).

There were 4 sampling periods:

- 3 weeks after introduction when the birds were 20 weeks of age,
- 12 weeks after introduction at the peak of lay at 29 weeks old,

- 23 weeks after introduction at mid-lay at 40 weeks old and
- 47 weeks after introduction at the end of lay at 64 weeks of age, just prior to the shed being de-stocked.

At each sampling period from each compartment, 6 birds from cages and 10 birds from the barn system were sampled for:

- corticosterone concentrations on the basis of a blood sample taken from the brachial vein (corticosterone is one of the so-named stress hormones and higher concentrations were expected in chronically stressed birds).

- corticosterone concentrations on the basis of a blood sample taken 45 min after an intramuscular injection of 12.5 IU a synthetic adrenocorticotrophic hormone (ACTH, 'Synacthen' from Ciba-Geigy; a pituitary hormone that stimulates the adrenal glands to synthesise and secrete corticosterone; chronically stressed animals have a higher response to ACTH). The assay method for corticosterone has been previously described (Barnett *et al.*, 1994).

- cell mediated immunity, to indicate the responsiveness of the immune system (chronically stressed animals have a lower response), assessed on the ability of white blood cells to kill bacteria (*Staphylococcus aureus)* in a laboratory based test using a blood sample. For this test 5 mL fresh blood was collected by syringe (coated with potassium-EDTA as an anti-coagulant) from the brachial vein, transferred into tubes and stored at room temperature. On transfer to the laboratory, the blood was washed twice in phosphate buffered saline and centrifuged at 3000 rpm for 10 min. 100 μL of 'buffy coat' (containing the white blood cells) was mixed with 400 μL of Hank's balanced solution. 10 μl of test bacteria (~5 x 10^6 cfu/mL) was added to each tube for 1 h. Each blood sample was tested in duplicate. After the incubation period, the cells were lysed with digitonin (0.1 % w/v) and various serial dilutions were cultured to determine the number of viable bacteria in each test sample.

- feather condition and cover using a subjective 4 point scoring system applied to the neck, breast, back, wings and tail was used. Score 4 was given for a part of the body having good plumage with no few or worn or otherwise deformed feathers. Score 1 was given for a part of the body with heavily damaged feathers with no or only very small areas being covered with feathers. This scoring system is that of Tauson (1984a).

- foot condition using a subjective 4 point scoring system. Score 4 was for a good condition of foot pads, digits and claw folds. Score 1 was a very poor foot condition with inflamed and/or bleeding lesions. This scoring system is that of Tauson (1984b).

- claw length, measured on the middle toe of both feet with vernier callipers.

- body weight.

In addition to the above sampling:
- eggs were collected at the second sampling period to examine microbial contamination. Microbial contamination was determined using standard methods (Anon., 1992). Six eggs were collected at the second sampling period (29 weeks of age) from the floor, egg belts and cages of each compartment. The eggs were collected to minimize any cross-contamination by handling each egg with a new sterile glove and storing each egg in a

sterile plastic bag. The plastic bags/eggs were transported to the laboratory at 4 °C. At the laboratory the external surface of each whole egg was sampled by rinsing and wet/dry swabbing the surface of the entire egg and transferring both the washings and the swabs to 9.9 mL of 0.1 % Peptone water (Oxoid). Egg shells were then cleaned by washing in warm running tap water, drying on paper towel and immersing the egg in 70 % ethanol for 10 min, draining and flaming. A hole was then cut in the egg, the contents transferred aseptically to a sterile jar and the contents were mixed by shaking. 5 g of mixture was transferred to another jar containing 45 mL of 0.1 % Peptone water (1:10) for further processing.

Liquids, either swab samples processed in a 'stomacher' or diluted egg mixtures, were diluted 10 fold and 2 x 1 mL aliquots removed from each dilution for internal total viable counts (TVC), *E. coli* and coliform counts. Aliquots of 100μL were used for TVC on external surface samples. In addition, batches of egg contents (within compartments and location) were pooled and 25 g diluted in 225 mL of buffered peptone water (Oxoid) for *Salmonella* detection. Total plate counts were prepared using the pour plate method and incubating at 25 °C for 48 h. *E. coli* and coliform counts were performed using Pertrifilm™ *E.coli* count plates (3M) and incubating at 37 °C for 48 h. Blue colonies associated with gas were confirmed as *E. coli.* Red colonies associated with gas were confirmed as other coliforms. Counts were performed on plates containing between 25 and 250 cfu and their numbers calculated using the mean count and dilution factors of the duplicate plates.

- physical egg quality measurements (egg weight, equatorial egg shell thickness, albumin quality, determined by measuring albumin height at the edge of the yolk mid way between the two chalazae and yolk colour were made on eggs collected at the 4 sampling periods.

- any sick/culled hens on the day of the fortnightly visits to the farm were taken for post mortem.

- faecal samples were collected for parasitological examination by standard methods, at each sampling period. The methods are based on those of Anonymous (1986).

- egg production was measured monthly for each compartment by research staff and for the shed by farm staff who made twice-daily collections of eggs and daily collections for dead birds. The compartment records are presented on the basis of hens housed. The shed records are presented on the basis of hen day egg production; the daily records were collated into weekly, and subsequently monthly, production and mortality figures.

- 30 hens at the start of the experiment and 48 hens at the end of the experiment (8 birds/treatment/compartment) were euthanased for bone strength determinations. Following euthanasia, the left femur and humerus were dissected, cleaned of tissue, wrapped in 'cling-wrap' sealed in plastic bags and stored at -18 °C for subsequent bone strength measurements. Bone strength was determined using a Lloyd 1000K Tensile Testing Machine and a 3-point bending jig (Lloyd Instruments Ltd., Fareham Hants, England). This equipment is routinely used in the food industry and applies an increasing load to a material (in this case bone) until it shears. The instrument parameters were a 5 kN load cell accelerating at 10 mm/min.

Bones were taken out of the cling wrap and placed in a single layer on a plastic slate tray to enable good air flow, thawed at 4 ^{o}C for approximately 7 h and placed in a humidity room (20 ^{o}C) overnight (16 h). The middle point of the exterior bone face (the outside edge of the bone while the chicken was alive) was the impact test point, as this was the 'face' that would have received the greatest breaking force in the live bird. The bone was supported on the bending jig at the 2 points that represented 55% of the bone length, measured from the mid point (this support distance was chosen as it represented the maximum length of a relatively consistent diameter of the shorter bone {humerus}).

Statistical analyses

The data from within each barn or cage compartment were averaged and most of these data were analysed by a two-way analysis of variance to determine the effects of treatment and age (Genstat, Lawes Agricultural Trust, Rothamsted Experimental Station, UK). Differences between means were determined by Least Significant Difference (Sokal and Rohlf, 1981). As the egg microbiology data were not balanced (the belt location was only represented in the Barn treatment) and eggs were only collected at one age, these data were analyzed in two ways. Firstly, for treatment effects by a one-way analysis of variance, excluding the belt data and secondly by a factorial analysis of variance within the Barn treatment for location (floor vs. belt) and egg surface (internal vs. external). The bone strength data were analyzed by separate one-way analyses of variance for treatment and time effects using the individual bird as the unit of measurement.

Results

Body weight was lower in the Barn than the Cage treatment ($P < 0.001$, Table 1) and increased with age (Table 1). There were no treatment effects on claw length ($P > 0.05$), although claws grew longer with age, with claws at 64 weeks of age being significantly longer than those at 20 and 29 weeks of age $P < 0.05$; Table 1). There were no treatment or age effects on the condition score of the footpads, clawfolds or digits. For example, the mean values for the left footpad, clawfolds and digits for the Barn and Cage treatments were 3.96 vs. 3.99, 3.99 vs. 3.80 and 4.00 vs. 3.92, respectively. There were no treatment effects on overall (total) feather condition and cover ($P > 0.05$; Table 2), although feather condition and cover scores were higher in the Barn treatment for the back ($P < 0.05$) and tail ($P < 0.001$) and higher in the Cage treatment for the base of tail ($P < 0.001$; Table 2). For all areas, feather condition and cover scores declined as the birds became older (Table 2). There was a significant interaction term ($P < 0.01$) for total plumage condition and cover score; at 20 and 29 weeks of age the score was higher in the Barn treatment (mean values for the Barn and Cage treatments were 3.98 vs 3.89 and 3.73 vs. 3.54 for 20 and 29 weeks of age, respectively; $P < 0.05$), while it was higher in the Cage treatment for the older ages (mean values for Barn and Cage treatments were 3.20 vs. 3.27 and 2.82 vs. 3.01 for 40 and 64 weeks of age, respectively; $P < 0.05$). There was a significant interaction term ($P < 0.05$) for the cover and condition score of the wings with a higher score in the Barn treatment at 29 weeks of age (3.67 vs 3.00); the condition and cover of the wings was similar at other ages.

Table 1. Effect of housing and age on body weight, corticosterone concentrations and immunological response

Parameter	TREATMENTS						LSD (P = 0.05)
	HOUSING		AGE (weeks)				
	Barn	Cage	20	29	40	64	
Body weight (kg)	2.01^{x}	2.25^{y}	1.98^{x}	2.10^{yp}	2.12^{yq}	2.32^{z}	0.013
Claw length (mm)	18.45	18.70	16.04^{a}	16.19^{a}	20.09^{ab}	21.99^{b}	5.692
Corticosterone 'at rest' (nmol/L)	1.54^{y}	0.46^{x}	1.65^{z}	1.26^{bxz}	0.70^{a}	0.39^{ax}	0.483
Corticosterone response to ACTH (nmol/L)	39.5	33.6	32.4	41.3	40.0	32.6	54.23
Immunological response (% bacteria surviving)	0.292^{x}	0.347^{y}	0.884^{z}	0.002^{px}	0.011^{qxy}	0.381^{y}	0.0074

$^{ab, pq, xyz,}$ different letters denote a significant difference at P < 0.05, P < 0.01 and P < 0.001, respectively.

Corticosterone concentrations were higher in the Barn treatment (P < 0.001) and mean concentrations in both treatments declined with age (Table 1). The immunology data showed marked variation in per cent of bacteria surviving between ages and this was probably associated with the varying number of 'starter' bacteria in the different tests (Table 1). The per cent of bacteria surviving was higher in the Cage than the Barn treatment (P < 0.001, Table 1).

At the first sampling period, at 20 weeks of age, faecal coccidial egg counts were extremely high in the samples from the Barn compared to the Cage treatment; numbers were 250,000+ vs. 9,233 oocysts/g of faecal material, respectively. By 29 weeks of age the numbers were 380 and 420, respectively and no oocysts were detected in the sample at 40 weeks of age. Round worm eggs were not apparent at 20 weeks of age, but by 29 weeks of age, eggs/g of faecal material were 545 vs. 40 for the Barn and Cage treatments, respectively, and by 40 weeks of age the numbers were 1,095 and 940, respectively.

The causes of mortality and parasite burdens changed during the course of the experiment (Table 3). After the initial coccidiosis problem a number of birds died from prolapse and smothering. Subsequently, mortalities were associated with vent pecking, peritonitis and salpingitis and towards the end of the experiment mortalities were associated with vent and uterine damage; some birds were found with egg contents in their digestive tract. Total mortalities for the barn and cage treatments were 10.8 and 5.6 %, respectively (the proportion of overall mortalities for the 2 treatments were statistically different by the Chi-square test; P < 0.05).

Table 2. Effect of housing and age on feather condition and cover

Parameter	TREATMENTS	
	HOUSING	AGE (weeks)

	Barn	Cage	20	29	40	64	LSD (P = 0.05)
Feather condition/cover score[1]							
Total plumage	3.43	3.43	3.94^{z}	3.64^{y}	3.24^{x}	2.91^{v}	0.012
Neck	3.58	3.25	4.00^{z}	3.50^{y}	3.17^{x}	3.00^{v}	0.088
Breast	3.42	3.42	4.00^{y}	4.00^{y}	3.00^{xp}	2.67^{q}	0.177
Back	3.67^{a}	3.92^{b}	4.00	4.00	3.83^{q}	3.33^{p}	0.177
Wings	3.42	3.25	4.00^{z}	3.33^{y}	3.00^{x}	3.00^{x}	0.088
Tail	3.18^{y}	2.90^{x}	3.59^{z}	3.07^{y}	2.94^{x}	2.55^{v}	0.010
Base of tail	3.40^{x}	3.70^{y}	4.00^{q}	3.85^{zp}	3.37^{y}	2.98^{x}	0.096
Vent	3.83	3.83	4.00	4.00	3.83	3.50	0.265

[ab, pq, vxyz,] different letters denote a significant difference at P < 0.05, P < 0.01 and P < 0.001, respectively; [1] feather score was over the range of 1 for birds having heavy damage with no or only very small areas being covered with feathers to 4 for birds having very good plumage with no few worn or deformed feathers.

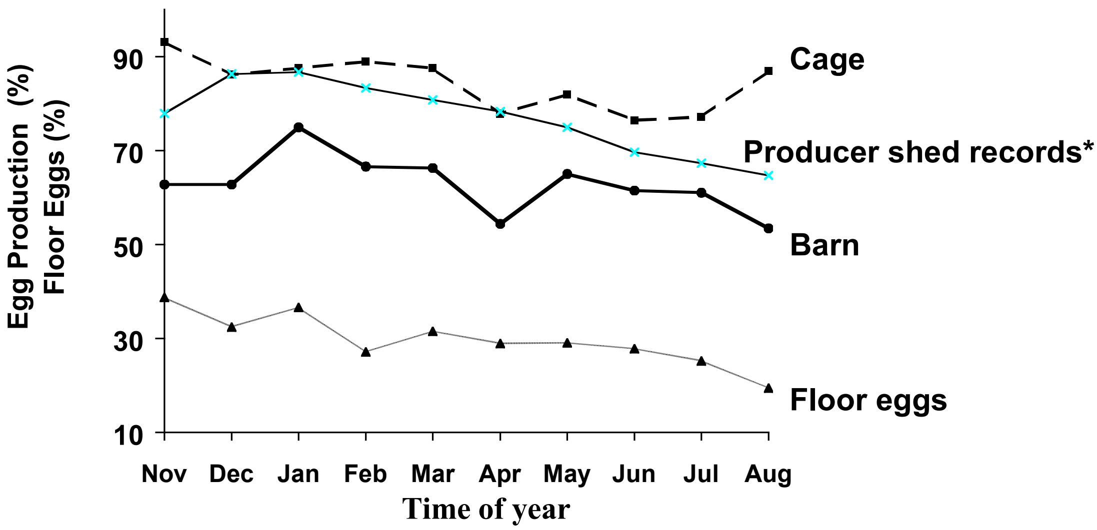
The monthly egg production data showed higher egg production in the Cage than the Barn treatment (based on both monthly research records for the compartments and weekly producer records for the shed) and a high proportion of floor eggs (floor eggs are represented in Figure 1 as part of the barn egg production and not an additional component) in the barn system, although the latter declined as the birds increased in age (Figure 1). There were no effects of housing treatment on egg weight (P > 0.05; Table 4) although egg weight increased with age, with progressive increases (P < 0.05) in egg weight from 20 to 29 weeks of age and 29 to 64 weeks of age (Table 4). There were no differences due to housing or age in albumin quality (P > 0.05; Table 4). Egg yolk colour score was lower (P < 0.01) in the Barn than the Cage treatment (Table 4). In the first sampling period, egg colour score was lower for the Barn than the Cage treatment (3.9 vs. 6.7 {P < 0.001) and except for the large improvement between the first and second sampling periods there were only small improvements between the second and fourth sampling periods (P < 0.01; Table 4). There was a significant interaction between housing and age for egg yolk colour score (P < 0.05); egg yolk colour score was better in the Cage treatment at all ages (P < 0.05), except for the final sampling period where the colour scores were similar (13.2 vs. 13.0 for the Barn and Cage treatments, respectively). There were no overall differences in equatorial egg shell thickness, although shells were slightly thicker at 29 and 40 weeks of age than at 20 and 64 weeks of age (P < 0.001; Table 4).

Table 3. Cause of death (based on post-mortem evidence) and parasite burdens during the course of the experiment. The predominant cause of death for the month is highlighted in bold. The numbers in parentheses refer to the number of birds examined. The birds sent for necropsy were all from the barn treatment.

MONTH	CAUSE OF DEATH	PARASITES
October	**coccidiosis** (3); vent damage egg binding (1)	Very high coccidiosis
December	**prolapses** of oviduct, uterus and intestine;	Round worms (floor); mites

	tumours; vent damage; **smother**? (9)	(floor); low mites (cages)
February	**vent pecking**; intestinal and oviduct prolapse (6)	
March	**coccidiosis** (2)	zero coccidiosis; round worms cage and floor
April	**vent pecking; peritonitis; salpingitis** (5)	
June	necrotic cloaca; peritonitis; salpingitis; (**egg eating occurring**) (3)	
August	**peritonitis; salpingitis** (3); vent damage; uterine damage (3)	round worms cages and floor; mites (floor)

Figure 1. MEAN EGG PRODUCTION PER COMPARTMENT AND FLOOR EGGS (%; from monthly research records)



* Shed hen day egg production (combined weekly data averaged over 4 week periods)

As indicated in the methods above, eggs were sampled at 29 weeks of age for *Salmonella, E. coli*, coliform bacteria and total viable counts. *Salmonella* could not be detected in any of the samples. As expected, the counts for *E. coli*, coliform bacteria and total viable counts were generally higher for the external egg surface than for the egg contents (Figures 2-4). The major difference was that the external counts in eggs collected from the floor was higher than from cage and the belt and this difference was significant for total viable counts and coliform bacteria ($P < 0.05$; Figures 2-4).

Table 4. Effect of housing and age on egg quality measurements.

	TREATMENTS	
Parameter	HOUSING	AGE (weeks)

	Barn	Cage	20	29	40	64	LSD (P = 0.05)
Egg weight (g)	62.1	63.4	51.8^{ap}	61.8^{b}	66.4^{abcq}	71.1^{c}	7.91
Haugh units	70.0	71.7	91.3	68.8	66.2	57.1	76.02
Roche colour score	10.1^{p}	11.2^{q}	5.31^{x}	12.03^{py}	12.06^{py}	13.08^{qy}	0.695
Egg shell thickness (mm)	0.42	0.40	0.40^{x}	0.43^{z}	0.42^{y}	0.40^{x}	0.0087

$^{abc, pq, xyz,}$ different letters denote a significant difference at $P < 0.05$, $P < 0.01$ and $P < 0.001$, respectively.

Figure 2. ***E. COLI*** **COUNTS**

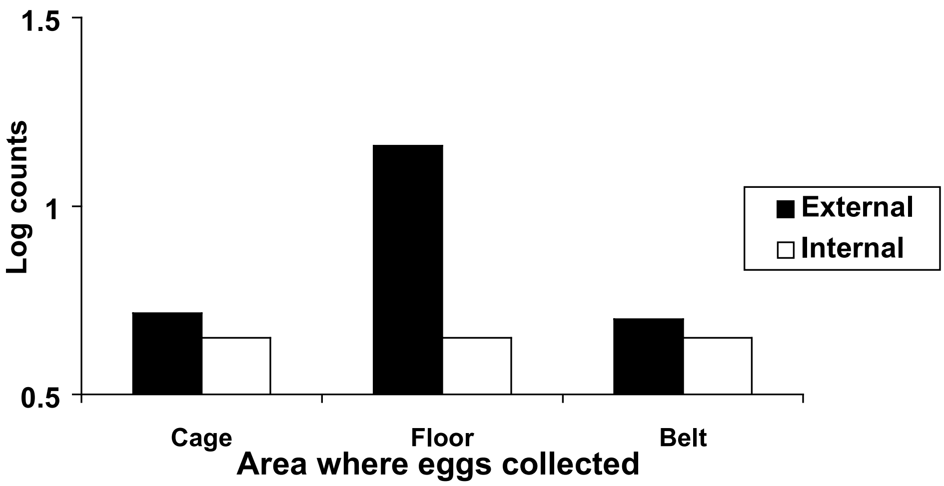


Figure 3. TOTAL VIABLE COUNTS (25 °C)

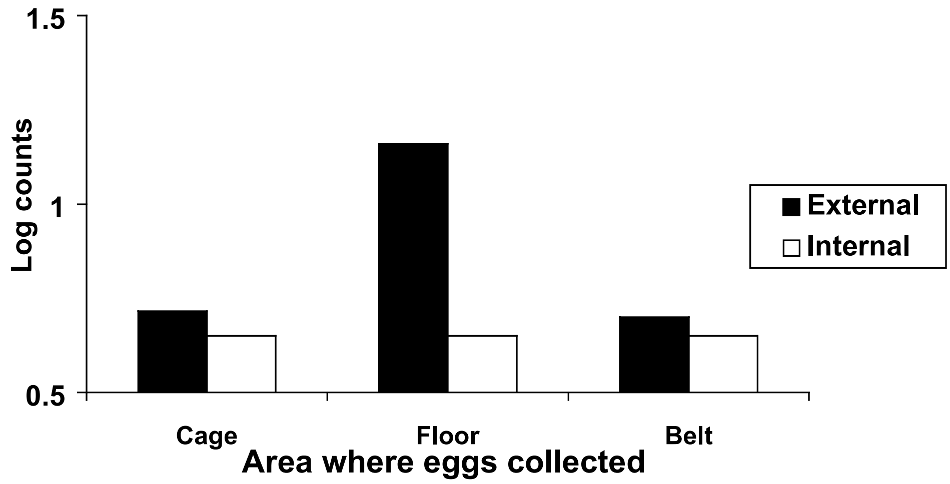
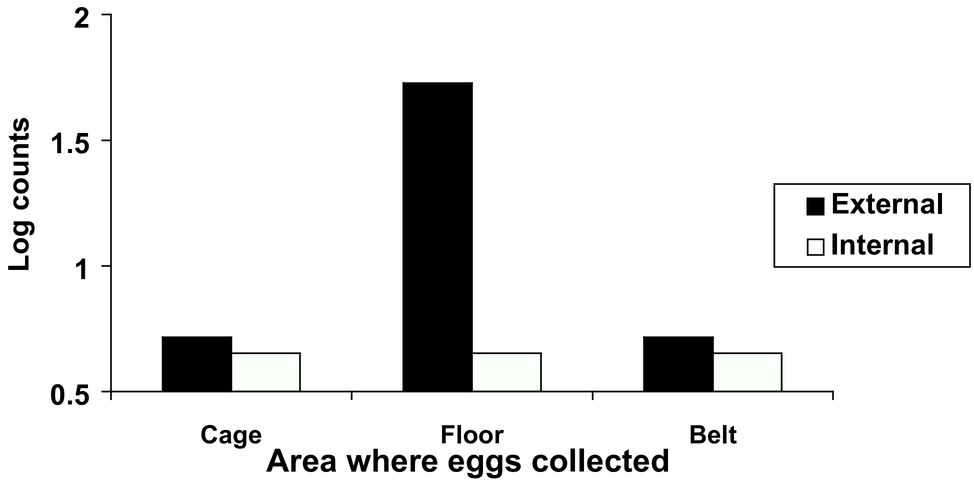


Figure 4. COLIFORM BACTERIA COUNTS



The bone strength data showed that the major effect was on bone strength in the Barn treatment. The humerus was stronger in the Barn than the Cage treatment ($P < 0.01$; Table 5) and while the femur strength was higher in the Barn treatment, the mean values approached a statistical difference ($P = 0.052$). Compared to bone strength at the start of the experiment, humerus strength declined as a consequence of housing in cages ($P < 0.001$). Femur strength showed no significant changes between the start and the end of the experiment ($P > 0.05$). Two humeri and one femur from birds in cages were identified as broken prior to testing of bone strength and these bones were either not tested or excluded from the analyses. There were no broken bones from the Barn treatment. The treatment difference in the number of broken bones was significantly different based on the Chi-square test ($P < 0.01$).

Table 5. Effect of housing on bone strength (Newtons); values are means with standard errors in parentheses.

Start of Experiment[1]		End of Experiment[2]			
Humerus	Femur	Humerus		Femur	
		Barn	Cage	Barn	Cage
152.7^{y} (11.16)	110.8 (10.69)	146.2^{q} (16.88)	81.8^{px} (8.09)	182.1 (30.56)	115.0 (10.68)

[1]N = 30; [2]N = 22 for the humerus in cages, 23 for the femur in cages and 24/treatment for the barn; ^{pq} different letters denote a significant difference at $P < 0.01$; ^{xy} different letters denote a significant difference at $P < 0.001$.

Discussion

It must be emphasized at the outset of this discussion that overall generic conclusions relating to the welfare of hens in barn and cage systems of housing should not be drawn from this study. This experiment compared a single design of barn hen system compared to cages in the same environment. There were a number of constraints and specifics in the experimental design and treatments, such as limited available locations for the installation of cages, a limited number of replicates per treatment, a single design of barn-system, a single cage-type with two birds per cage and a space allowance of 752 cm^2/hen, and eggs collected from belts for the barn hens compared to eggs collected manually from roll-out trays for the caged hens; these constraints and specifics make it very difficult to make generalized statements about generic systems.

Bearing the above in mind, both systems of housing the birds had advantages and disadvantages. The experiment showed that barn hens, in comparison to the caged birds, had a lower body weight, better feather condition and cover until 29 weeks of age, poorer feather condition and cover at 40 and 64 weeks of age, higher levels of stress (based on corticosterone concentrations from a 'spot-sample'), higher immunological responsiveness (based on limited evidence from an *in vitro* test examining the ability of white blood cells to kill bacteria), higher parasite burdens, particularly at 20 weeks of age, poorer egg microbial quality, particularly from the floor eggs, higher bone strength and fewer broken bones, lower egg production and a lower egg colour score, particularly at 20 weeks of age.

The mortalities during the course of the experiment, based on the few birds that were necropsied, showed that the cause of death changed over time. Early in the experimental period there was considerable coccidiosis infestation which resulted in bird deaths (preventative treatments are suggested in part 2 of this report). This was presumably due to the farm's system of cage rearing which precluded continued exposure to coccidia and thus prevented an early development and maintenance of immunity. While roundworms were present in the barn birds, the numbers were not considered sufficiently high to be a health problem; nevertheless to minimize the low risk of incorporation into the egg (a product quality/marketing issue), a roundworm treatment should be used (see part 2 of this report). This 'parasitic' phase was followed by evidence of smothering. Smothering behaviour was observed on several visits to the farm and is a potential problem and probably difficult to control in open-sided sheds, where light levels cannot be controlled. Birds appeared to show a very strong preference to be situated in certain restricted locations, generally near a corner or along a wall. The motivation to be in that location appeared, at times, so strong, that birds at ground level were apparently smothered by other similarly motivated birds in the 'group'. Later mortalities were associated with a number of conditions including vent pecking, prolapse and peritonitis. There was post-mortem evidence of egg eating in the Barn treatment towards the end of the experiment and this coincided with visual observations of egg pecking during visits to the shed and particularly when collecting floor eggs during (monthly) periods of egg collection.

Poor egg yolk colour in the first sampling period may have been due to either variable food intake, typical of barn hens (Parkinson, personal communication), or the coccidial infection that was evident at this time. Also, it is likely that the higher killing rate of bacteria in the barn system merely reflects the increased 'challenges' received by the birds on the floor, as indicated by the higher parasite loads rather than evidence of a less compromised immune system. The *in vitro* immunology test was chosen as an indicator of non-specific immunity in this experiment as *in vivo* tests would have interfered with the unit's profitability or operation because of the need to withhold eggs or isolate treated birds. However, the small differences observed indicate that either there was little evidence of immunosuppression or that the test was inappropriate. The efficacy of the test to indicate immunosuppression as a result of a chronic stress response needs to be examined in an experimental situation in which hens are known to be immunocompromised and chronically stressed.

The corticosterone data showed a considerably higher concentration in birds from the barn compared to the cage system. There is some acceptance in the general literature that evidence of a chronic stress response, in part, based on adrenal corticosteroid concentrations, suggests reduced welfare and readers are referred to the following papers for the arguments for this proposition (Dantzer *et al.*, 1983; Dantzer and Mormede, 1983; Moberg, 1985; Barnett and Hutson 1987; Barnett and Hemsworth, 1990). Based on the literature on corticosterone concentrations in cages and non-cage systems (floor pens and yards), there is no unequivocal evidence that level of confinement *per se* has any consequences for the welfare of the laying hen although the data are equivocal. For example, Koelkebeck and Cain (1984) have shown that corticosterone concentrations were similar in cages and outside range pens (7,430 cm^2/bird), while corticosterone concentrations in floor pens can be higher (Edens *et al.*, 1982; Craig *et al.*, 1986; Barnett *et al.*, 1997a; 1997b), lower (Gibson *et al.*, 1986) or not different (Craig and Craig, 1985) than in some cages and in part these differences appear to depend on the space allowance and/or group size of birds in cages (the literature has been reviewed; see Hemsworth and Barnett, 1993). The evidence to implicate changes in stress physiology with changes in either group size or space allowance, independently of the other is poor, although increasing stocking density is associated with increased in corticosterone concentrations (Mench *et al.*, 1986; Koelkebeck *et al.*, 1987); however, birds in single-bird cages can show lower corticosterone concentrations than birds in 2-bird cages (Barnett *et al.*, 1997a). There is no information on the effects of space allowance on corticosterone concentrations in large groups. Interestingly, some production data showed consistent trends for egg production to increase as space decreased from 2,980 to 1,580 cm^2/birds and from 1,050 to 940 cm^2/bird (Appleby *et al.*, 1988).

The corticosterone data in the present experiment provide *prima facie* evidence for a chronic stress response in the Barn treatment. However, while there are no supporting physiological data, there are supporting production data. On the basis of known consequences of a chronic stress response (see Barnett and Hutson, 1987), it was expected that concomitant changes would have been evident in the birds' responsiveness to ACTH (an increased response was expected while the experiment showed there was no change) and/or in their responsiveness to an immune challenge (a reduced response was expected while the experiment showed an increased response). The lower growth rate (based on evidence of a lower body weight during the experiment), lower egg production (i.e. impaired reproductive performance) and higher parasite burdens (*a priori* evidence of immunosuppression) concomitant with the elevated corticosterone concentrations in the barn hens can be interpreted as evidence for a chronic stress response. Thus, one interpretation of the present experiment is that it provides limited evidence for a chronic stress response associated with the barn hen system.

The egg production data collected by research staff once per month and the figures presented on mean egg production were based on hens housed and thus do not take mortalities into account. Thus, while the monthly measurements are likely to be an inaccurate measure of daily egg production, the relatively lower production in the barn system is likely to be real. The producer's records for hen day egg production for the shed, that take mortalities into account, also indicate lower production in the barn system than cages. Further evidence for a lower egg production in the barn system is the lower body weights from birds in this system which would be expected to result in lower overall production. The overall poor performance in terms of body weight and egg production is an area that requires further research. There are a number of possible contributing factors, such as inadequate dietary composition associated with an increased energy requirement, inadequate feeder places (it is likely that feeder placement, numbers and design, are based on broiler production systems where the social behaviour of birds is likely to be markedly different) and increased aggression or a change in social behaviour around the feeders resulting in displacement and/or food wastage. There are some parallels with pigs where it has been shown that pigs in large groups do not reach their genetic potential for growth (Chapple, 1993).

Floor eggs were a significant problem at this farm, although the incidence declined with time. Other local producers are reportedly achieving less than 5 % floor eggs, albeit with a different design of shed. Features that may reduce the incidence of floor eggs are introducing birds to the barn system at a younger age (so that they can learn the location of nest boxes), rearing birds in a barn (ie. on the floor rather than in cages) with perches in the location of the layer-phase nest boxes, partially slatted raised floors incorporating the feeding and drinking systems and adjacent to the nest boxes (to get birds off the floor and encourage nest box use) and providing limited access to the nests (by closing them off at night to encourage an association between nest box availability and egg laying). Overseas experience with alternative systems would also suggest that a low incidence of floor eggs can be achieved; in a survey of 29 aviary systems in The Netherlands the mean percentage of floor eggs was 5.2 % and ranged from 0.9-13.9 % (Horne, 1997).

In this experiment the comparisons of microbial egg quality were constrained by having a manual system for cages compared to an automated system for the eggs laid in nest boxes in the barn system. Nevertheless, the floor eggs from the Barn treatment had a poorer microbial quality, based on the increased counts of *E. coli,* coliform bacteria and total viable counts. Reducing floor eggs will reduce this problem, and it is assumed that washing eggs may also reduce the bacterial count, although this was not been determined in this experiment. There was no evidence of *Salmonella* contamination in any of the eggs sampled.

This study has shown bone strength is higher in birds in the barn system, with the major impact being a loss in bone strength in the humeri of caged hens. There were also 3 birds (6.5 %) with broken bones from cages compared to 0 % from the barn system, identified at the time of bone strength determination. While it is possible the breakages occurred after the end of the treatment period, the finding of weaker bones in caged birds is a relatively consistent one in the literature (McLean *et al.*, 1986; Knowles, 1990; Noorgaard-Nielsen, 1990; Gregory *et al.*, 1991; Abrahamsson and Tauson, 1995). The issue of weak and broken bones is a serious welfare issue that needs to be addressed, particularly but not exclusively, for birds in cages. Twenty nine per cent of laying hens from cages and 14 % from free range systems have a broken bone by the time they reach the waterbath stunner at the abattoir, as a consequence of handling and transport (Gregory and Wilkins, 1989; Gregory *et al.*, 1990); similar incidences of broken bones have been reported in Australian flocks (Jongman and Parkinson, 1995). Some of these breakages occur as a result of cage design, and certainly improved door design (e.g. S-shaped, full width doors as described in Tauson {1986} and Elson {1990}) improves access and should reduce the risk of bone breakages when removing birds from cages. However, changing the design of the door to reduce the chance of breaking bones during handling may not be a very acceptable solution to the problem. It would obviously be preferable if bone strength and handling at depopulation were improved so that the risk of broken bones is reduced. The provision of perches in conventional cages improves bone strength (Gregory *et al.*, 1991), although there can be detrimental consequences on production or egg quality (Ruszler and Quisenberry, 1970; Tauson, 1986*b*; Abrahamsson and Tauson, 1993); the literature on perches in conventional cages has been comprehensively reviewed (Ekstrand and Keeling, 1994). However, while there appear to be clear advantages to the strength of the leg bones by provision of perches, the effects of perches on non-load bearing bones are unclear. These latter bones may derive no benefit from perches (Barnett and Glatz, 1997b) or be adversely affected by perches; Appleby (1993), Appleby *et al.* (1993), Abrahamsson and Tauson (1993) and Engstrom and Schaller (1993) reported damage to the sternum due to perches.

As the range of bone damage between flocks varies from 0-53 %, this suggests that an understanding of the factors involved will reduce the magnitude of the problem (Gregory and Wilkins, 1992). Factors determined to date that can reduce the incidence of broken bones are rearing pullets in cages (as occurred in the present experiment) instead of on deep litter (although this may pose other welfare concerns), delayed onset of sexual maturity, opportunity to exercise, depopulating cages by catching and holding birds by two legs and modifications (as yet undetermined) to the shackling procedure (Gregory and Wilkins, 1992). Other factors such as lighting regimes have not affected bone strength (Gregory *et al.*, 1993), while using drugs (bisphosphonates) developed for treatment of osteoporosis in humans improve bone morphology (Thorp *et al.*, 1993) and a study by Koelkebeck *et al.* (1993) showed an increase in bone strength by providing carbonated drinking water during warm weather. Also, the relationships between diet, growth rate, egg production and osteoporosis, being developed into a model of osteoporosis by Parkinson *et al.* (1996), should result in practical methods of dietary manipulation to reduce the incidence of osteoporosis.

In conclusion, both housing systems have advantages and disadvantages for both welfare and/or production. Based only on the findings of the present experiment, the main advantages of the barn system were an increased bone strength and a better feather condition and cover in younger birds, while the main disadvantages appeared to be the increased parasite burdens and a higher level of stress and from a production viewpoint a lower egg production and a relatively high incidence of floor eggs and an associated microbial contamination. The main advantages of the cages were a lower level of stress, improved body weight, better feather condition and cover in the older birds, lower parasite burdens and from a production viewpoint a better egg production and quality and no floor eggs, while the main disadvantages appeared to be weaker bones and limited evidence of broken bones. However, while the experiment (and the literature) are too limited to extrapolate these findings to all barn laying hen production systems, they provide an insight to the areas to target to improve the efficiency and perhaps welfare in barn hen systems. It must be remembered that non-cage systems of housing laying hens have been developed, in recent times, on the basis of industry experience and with the imperative of "getting them to work". Thus, there have been very limited scientific inputs into the consequences of the designs. It would not be unexpected that with time, to allow both greater industry experience and scientific inputs, that a number of the apparent problems can be overcome.

REPORT ON A WORKSHOP ON BARN HEN PRODUCTION *(held on 23 October 1997 at VIAS, Attwood)*:

Introduction

Over the last twelve months (i.e. 1996-1997) there has been some significant investment in technology for alternative (Barn) egg production systems. This technology consists primarily of automated nesting systems and specialized slats for use as an adjunct to the nesting systems. The number of hens in these higher technology alternatives has risen from about 25,000 to in excess of 80,000 hens, and there is some degree of standardisation in equipment and shed lay out.

This investment has occurred as a consequence of technology transferred from European and Scandinavian countries and there is a requirement to evaluate these systems for welfare standards, productivity and product safety. At this stage, it seems likely that these barn systems may represent the best compromise between economic efficiency and a system which meets the perceived behavioural needs of the bird and they certainly provide increased choice for the bird. It is clear however that there is a need to identify the most appropriate European technologies and to refine these in Australia.

The costs of the automated nesting systems, slats and feeding/drinking systems are estimated at $10/hen housed and the shedding at anything from $5 to $10/hen housed (Parkinson, personal communication). (Note: estimated costs in this part of the report are based on 1997 prices). However, irrespective of the precise dollar costs, while the fit-out costs/hen are cheaper than for cage systems, the capital (building) costs are considerably higher per hen because of the considerably lower density of birds in the barn system.

To help generate a general discussion of issues relating to barn hen production the data from the experiment described in the first part of this report were used to raise potential problems that had been identified at a single farm.

Issues Identified and Some Solutions

Eleven areas were identified as potential problems or areas for improvement. These were:

- Lower body weight
- Lower egg production and egg weight
- Incidence of floor eggs
- Microbiological quality
- Parasite control
- Guidelines for maximum number of birds per shed
- Guidelines for shed design and equipment options
- Social behaviour of birds and rearing effects
- Beak trimming
- On-farm data recording

- Marketing

- **Lower body weight in barn hen**
  Thresholds of body weight for high levels of egg production have been established for cage systems and these have been well researched in Australia. Clearly the body weights of flocks in barn systems are frequently below these thresholds. Research needs to be undertaken to evaluate these relationships for litter based systems where the energy requirements are likely to be higher.

- **Lower egg production and egg weight in barn pens**
  At this stage the lower egg production is consistent with the lower body weight and the relationship between weight management and egg production needs to be defined.

- **Incidence of floor eggs**
  The discussions highlighted that there are some rearing/nesting/slat/management systems which are achieving a very low incidence of floor eggs and the relative impact of the different components need to be determined.

- **Microbiological quality**
  The studies on microbiological standards of eggs need to be extended to include those nesting systems which are operating at a high level of efficiency (e.g. < 1% floor egg)

- **Parasite control** *(information provided by G. Underwood and R. Cumming)*
  It is to be noted that the following information is only intended as a guide. Producers are strongly encouraged to seek expert veterinary advice so that a parasite control programme can be tailored for an individual's farm. Parasitological problems with farming intensive chickens in a barn system include:

  Internal parasites
  <u>Coccidiosis</u>
  Coccidiosis should not be a problem in pullet flocks that are properly immune, but the use of cage reared birds or pullet flocks that do not have effective immunity increase the risk of infection (e.g. as occurred in part 1 of this report). Pullets intended for production on the floor should ideally be reared on litter from day-old. A common practice is to include a coccidiostat in the feed at a preventative level for the first 6-8 weeks. This is then progressively reduced, aiming to have the birds with no coccidiostat in the feed by 12-14 weeks. Careful husbandry is required during this latter period and medication with a different drug from that used in the feed should be administered via the drinking water immediately signs of infection are observed in the pullets.

  Traditionally, anticoccidial drugs have been used in the feed ration at variable periods, or, water medication given at the first sign of infection in the flock. There is a new generation of coccidial control being developed in Australia. Over the past few years preparations containing 4 major *Eimeria* species (*acervulina, maxima, necatrix* and *tenella*) have been given to young chicks followed by a controlled and strategic treatment program 10 days later. New precocial strains have and are being developed, 2 of which have been included in the available product. The current following treatment program has not changed:

Days 7-10, dose with coccidial vaccine either in-water or on-feed;
10 days later, give 2 days of Baycox in-water treatment;
provide fresh water for the following 4 days;
give another 2 days Baycox in-water.

The material is provided in a stable liquid form and can be stored for several weeks at 4 °C. The estimated cost of the material is 10 cents per dose.

Helminths or worms

There are 2 main types of worms affecting commercial poultry. Round worms or ascarids are the most common form and all chickens in contact with their faeces should be treated prophylactically to purge developing worm burdens every 6 weeks. *Capillaria sp.* may pose a problem for flocks on the litter. Although the large round worm (*Ascaridia galli*) can grow up to 10 cm long, this is a very well adapted parasite and causes minimal damage or harm to the host. It is commonly found in birds on the floor and blamed for all sorts of problems it does not cause in poultry. It is really only pathogenic in chickens less than 6-8 weeks of age. Birds older than this and on adequate diets are fairly resistant to infection. However, the possibility of a round worm being incorporated into an egg, although very rare, means the layers should be treated.

Ideally, pullets should be dewormed a week or two before they are introduced to their laying quarters. The laying shed should be physically very well cleaned, with all old litter material being removed; it must be appreciated that the worm egg is extremely resistant to various chemicals. The pullets should then be dewormed a month after introduction to their new shed, preferably with a broad spectrum dewormer (e.g. Nilverm or Safersan). Thereafter, the layers could be dewormed at 6 week intervals with a piperazine salt only. The producer could well examine any dead birds for the presence of round worms. This is a simple procedure and will provide some useful information.

There appear to be only 2 registered products:

"**Nilverm for pig and poultry**" which contains levamisole as the active ingredient. This medicant is given in the water and has a bitter taste which can be offset by mixing up to 2 kg of dextrose per 900 L of drinking water (note: lines must be flushed following dextrose addition to prevent blockages of the nipples where used). There is no with-holding period for eggs associated with the use of this product.

"**Safersan**" which contains piperazine carbon disulfide. Piperazine is a better tasting product and therefore may be consumed more readily by the chickens being treated. Again there is no withholding on the eggs produced while hens are being treated.

External parasites (such as lice, Northern fowl mite and red mite)

Lice

Lice cause very little damage to birds and again tend to be overemphasized as a cause of poor production. Point of lay pullets should have been reared in isolation from adult birds and should be free from lice. These parasites spend their entire life on the bird, dying out in about 5-6 days when removed from their host. Thus the presence of lice generally means the young birds have been in close contact with older birds. Lice are insects and have 6 legs.

Red mite and Northern fowl mite
Mites are arachnids ('spiders'), have 8 legs and are blood suckers and therefore are far more pathogenic to the birds. Red mite hide in cracks and crevices in poultry sheds, usually coming out at night for a blood meal when the birds are sleeping. They require a still host and somewhere to hide afterwards. When these opportunities are not present, they will often parasitise birds in nests during the daytime. Mite eggs are laid in cracks and look like little salt granules. The life cycle is short (about 10 days from egg to adult) and enormous populations can develop very rapidly, particularly in warmer weather. Affected birds will have a drop in production. The parasite can be identified by looking for little red insects, about 1.5 mm round and red in colour when engorged with blood.

All areas where the mites may be hiding should be thoroughly sprayed (see suggested products below) and a second spraying carried out 7 days later. It is important to regularly check for red mite as they consistently reinfect poultry sheds, with rodents and wild birds probably assisting their spread. When introducing pullets into a shed that has had Red mite problems, it must be remembered that this parasite can live for 37 weeks without food. The mites are stimulated by the presence of birds and will wait until a depopulated house is repopulated. For this reason it is advisable to thoroughly treat the shed for Red mite 5 or 6 days after introduction of the new pullets.

The Northern fowl mite spends its entire life on the bird, heavily parasitising the feathers below the vent. Diagnosis is made by examining the feathers below the vent in a number of birds. Treatment is difficult as the birds will require individual dusting or spraying in the affected area.

Both these parasites can cause economic loss and Red mite in particular should not be underestimated. The registered products available for mite and lice control are:

"**Alfacron 500**" contains an anticholinesterase and is therefore effective against a wide range of external parasites. The product should not be used on birds less than 7 days of age. There is a nil withholding period for eggs. The product can be used to spray the environment of birds after evacuation or food holding silos at a high concentration. Lower concentrations may be used to spray the birds directly. (Poisons schedule S5 - poisons of a hazardous nature that must be readily available to the public but require caution in handling, storage and use).

"**Avian Mite and Lice Spray**" is a permethrin based product which is very safe (poisons schedule nil). It is only practical for small numbers of birds and comes as a spray. There is a nil withholding period for eggs.

"**Keydust**" contains maldison and carbaryl. It is a powder and can be applied to both birds and environment. There is a nil withholding period for eggs. (Poisons schedule S6 - poisons that must be available to the public but are of a more hazardous or poisonous nature than those classified in Schedule 5).

- **Guidelines for maximum number of birds per shed**

The UK Farm Animal Welfare Council has suggested that flock sizes for barn systems be restricted to 2,000 hens, but most of the commercial developments in Europe are operating with a maximum flock size of 5,000-10,000 hens. At this stage maximum flock size should probably be flexible until there is scientific evidence to suggest a stronger stance.

- **Guidelines for shed design and equipment options**
  This issue requires more advice from European Poultry Equipment manufacturers. Producers should only accept the 'latest' model from overseas along with documented evidence of its comparative effectiveness. 'Dumping' of products is a potential issue.

- **Social behaviour of birds and rearing effects**
  Some systematic analysis of rearing management and subsequent behaviour is required. Initial information could be obtained by quantifying different levels of flock aggression in the laying phase. In addition, comments are frequently made of the high level of approach behaviour towards humans in the barn system. Quantitative tests need to be applied to describe flock aggression and responses to humans. In relation to the latter, tests have been developed for broiler chickens (Hemsworth *et al.*, 1994) and could be readily adapted for barn hens.

- **Beak trimming**
  Industry practice for barn lay flocks is for a double beak trim. However, there is some recent evidence that a single trim between day old to 10 days of age may be superior in reducing chronic pain (evidenced by fewer neuromas; Lunam *et al.*, 1998) and UK recommendations are for a single trim only (Gentle, 1998). There is a need to test the robustness of the early beak trim for barn hens in well controlled experimentation, and to begin to identify other variables that interact with pecking behaviours. An important long term objective should be to move to the early beak trim and then to develop systems which eliminate the need for trimming. Beak trimming has been recently reviewed (Gentle, 1998).

- **On-farm data recording**
  It was agreed that because of the lack of information on barn systems in Australia that on-farm records could provide valuable information. RSPCA representatives at the workshop agreed they were probably in a position to collect some data during the regular inspections associated with their accreditation process for barn hens. Important data are farm numbers, flock sizes, floor egg incidence, mortalities, cannibalism outbreaks, egg production estimates and estimates of flock body weights.
- **Marketing**
  It was agreed that better marketing was required for barn hens. It was considered that it would probably be counter-productive for the various sectors of the egg industry to focus marketing on a (perceptual) comparison of cage, barn and free-range systems. A better long-term approach would be for education of consumers about the different systems and let market forces control market share. While it was agreed that supermarkets have a role in this and that current display of eggs in supermarkets was generally poor, there was no agreement on how the involvement of supermarkets in these issues could be improved. There was some limited discussion on the supply problems of free range eggs because of the relatively small numbers of hens held by free range producers and the resultant opportunistic entry and egress from the industry.

Research Priorities

Future research approaches should involve additional longitudinal studies of elite flocks or systems, and/or studies across the industry of several systems to identify variation due to management and or housing systems. As a result of the workshop the following research priorities were identified:

Short Term

- Study factors affecting nesting behaviour that reduce floor eggs.

- Examine egg microbial quality from farms identified with superior nesting performance.

- Apply existing methodology (for broilers) to survey the behavioural responses of hens in barn systems to humans.

Medium Term

- Study flock body weights and uniformity in relationship to flock production in barn systems, and relate these data to body weight patterns identified in cage systems.

- Investigate the use of a single early beak trim in barn systems.

Long Term

- Develop methods to quantify flock aggression and its impact on pecking behaviour and cannibalism.
- Study management variation and its impacts on variation in body weight, production and behaviour.
- Determine if there is an optimum or maximum group size for barn hens from both management and welfare perspectives.

Concluding Comments

There was considerable enthusiasm for the barn hen production system. While it must be recognized that this sector of the egg industry is in its early stages of development in Australia, there is an expectation that, given additional research and industry experience, both level of production and bird health will be equivalent to that achieved in cage systems. This expectation is based on the results being achieved overseas and local experience. Thus, barn hen production is likely to fill an important niche in the community’s requirements for non-cage eggs.

Implications

- This project has identified some potential advantages and disadvantages of cage and barn hen systems of laying hen production. However, while the above data suggest some welfare and/or production problems associated with both production systems, it must be emphasized that this experiment examined a single barn hen system and a single cage type. Thus, the constraints this imposed means the findings of this experiment cannot be extrapolated to a generic system of barn hen production.
- It must also be recognized that the barn hen sector of the egg industry is in its early stages of development in Australia and that there is an expectation that, given additional research and industry experience, both level of production and bird health will be equivalent to that achieved in cage systems. This expectation is based on the results being achieved overseas and local experience. Thus, barn hen production is likely to fill an important niche in the community's requirements for non-cage eggs.
- Based on the above and notwithstanding the numerous findings of the project, it is premature to extrapolate the findings of this project to general industry recommendations on barn hen production systems. Thus, other than the identified needs for further research and the identified potential problems associated with egg production systems, it is premature to identify the implications of this project. These identified needs and potential problems are provided in the following section (see Recommendations).

Recommendations

- Further comparative experiments of the different laying hen production systems are required before the findings of the present project can be extrapolated to barn production systems in general.
- Thresholds of body weight for high levels of egg production have been established for cage systems and these have been well researched in Australia. The body weights of flocks in barn systems are frequently below these thresholds and research needs to be undertaken to evaluate these relationships and their interactions with social behaviour in large groups where the energy requirements may be higher, in part due to a change in social behaviour.
- The lower egg production in the barn system is consistent with the lower body weight and the relationship between body weight management and egg production needs to be defined.
- The practical solutions to reduce floor eggs need to be documented (perhaps researched) and made available to producers interested in establishing non-caged flocks.
- This report provides some information on parasite control and this information should be made available to industry.
- Most of the commercial developments in non-cage systems in Europe are operating with a maximum flock size of 5,000-10,000 hens. At this stage, maximum flock size, in Australia, should be flexible until there is scientific evidence to suggest a stronger stance. It need to be determined if there is an optimum or maximum group size for barn hens from both management and welfare perspectives.
- Some systematic analysis of rearing management and subsequent behaviour is required for barn hen production. Initial information could be obtained by quantifying different levels of flock aggression in the laying phase.
- Comments are frequently made of the high level of approach behaviour towards humans in the barn system. Existing methodology (for broilers) should be applied/adapted to survey the behavioural responses of hens in barn systems to humans.
- There is a need to test the robustness of the early beak trim (i.e. elimination of a retrim) in well controlled experimentation for barn hens, and to begin to identify other variables that interact with pecking behaviours.
- Because of the lack of information on barn systems in Australia, on-farm records could provide valuable information. Important data are farm numbers, flock sizes, floor egg incidence, mortalities, cannibalism outbreaks, egg production and flock body weights.
- Examine egg microbial quality at farms identified with superior nesting performance.

Communications Strategy

It is envisaged that the findings from this project will be communicated in the following ways:

- The findings will be presented to poultry researchers in Australia at the annual meeting of the Australian Poultry Science Symposium.
- The findings will be communicated to industry by publishing the findings in an ‘industry’ journal, such as Milne’s Poultry Digest, and discussing the findings at producer meetings.
- The findings will be presented to the broader scientific community by submitting a research paper for publication, based on the findings of the project, to a scientific journal.

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