

Comparative Assessment of Layer Hen Welfare in New Zealand

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By Hugh Black, AsureQuality Limited and
Neil Christensen, Avivet Limited

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Requests for further copies should be directed to:

Strategic Science Team
Policy and Risk Directorate
MAF Biosecurity New Zealand
P O Box 2526
WELLINGTON

Telephone: 0800 00 83 33
Facsimile: 04-894 0300

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1. Summary

Aims:

The aim of this survey was to conduct a science-based comparative assessment of the welfare of laying hens in commercial production systems in New Zealand. The collection and analysis of data were focused on outcomes in terms of hen welfare.

Methods:

The survey was carried out on a selection of 60 layer hen farms in the categories: large cage, small cage, large free range, small free range, organic free range and barn categories. The farms were selected to provide balanced representation of the two major brown layer breeds (Shaver Brown, Hyline Brown) farmed in New Zealand, plus a representation of the locally-bred Ranger bird used at the time the survey was carried out by a small number of organic farms. The farms were also selected to represent the geographical spread of egg production in New Zealand, and care was taken to include representation of all the major suppliers of equipment. Data were collected on farm-level variables and bird-level variables, affecting hen welfare, taking account of both biological function and feelings approaches to animal welfare assessment. In cage systems, thirty birds were assessed on each farm. In free range and barn systems, 30 birds were weighed but the behavioural assessment was carried out on a range of birds within easily assessable distance. The average numbers assessed in the non-cage groups ranged between 61 and 128 birds. Two farm visit assessments were made, the first soon after peak lay (average age at first visit: 32 weeks), and the second examining birds from the same flock towards the end of their laying period (average age at second visit: 62 weeks).

Results:

The report presents the findings of the two series of farm visit assessments. The results are presented in 35 tables describing the results of the assessment of overall farm practices (tables 1- 17), individual bird level physical assessment (tables 18-25), flock level performance (tables 26-31), flock behavioural assessment (tables 32, 33) and faecal corticosterone analysis (tables 34, 35). Statistical analysis of these results is provided. The tables are supplemented by a number of figures and graphs.

Discussion:

Our findings indicate that cage and free range layer hens are similarly adapted to their environments, and show similar stress levels as measured by faecal corticosterone tests. Significant differences in mortality, feather cover and wound prevalence were found between farm types. A range of management standards was found within each farming system, though large cage farms systems showed least internal variation.

Conclusions:

In its 2004 report on the draft Layer Hens Code of Welfare, NAWAC stated that it was “unable to recommend replacement of current cage systems with alternative systems until such time as it can be shown that, in comparison to current cage systems, alternative systems, in the context of supplying New Zealand’s ongoing egg consumption needs, would consistently provide better welfare outcomes for birds and be economically viable”. This report backs up this conclusion and indicates that little has changed in the interim.

Relevance:

The science-based approach of this work will lead to improved layer hen welfare outcomes via the revised codes of welfare.

2. Introduction

New Zealand's estimated 3.0 million laying hens produced around 75 million dozen (900million) eggs in 2006. Over 85 percent of eggs are sold as table eggs within the domestic market, with the remainder used in the baking and catering industries. Retail sales of eggs were worth over \$200 million in 2006. Total egg production has slowly increased over the past decade, with an increase in per capita consumption also - now around 218 eggs per person annually. Nearly 90 percent of eggs produced in New Zealand are from cage production systems, with the balance being produced in free range or barn egg production systems, (Egg Producers Federation of New Zealand accessed at <http://www.eggfarmers.org.nz/background.asp>).

The National Animal Welfare Advisory Committee (NAWAC) is responsible for developing Codes of Welfare, which have legal force, and recommending them to the Minister for Agriculture for approval. The Animal Welfare (Layer Hens) Code of Welfare 2005 (the Code), which came into force in 2005 and covers all aspects of care and management of layer hens kept for egg production, will be reviewed by NAWAC in 2009. At this time the committee will decide whether cages for layer hens should continue to be used, be used in modified form, or be phased out.

Little published data is available regarding the assessment of hen welfare in the New Zealand layer industry. To assist in its deliberations on the animal welfare outcomes of different layer hen management systems in the context of New Zealand's egg production requirements, NAWAC required a comprehensive, comparative assessment of the welfare of layer hens in the various housing systems currently in commercial use in New Zealand. MAF Biosecurity New Zealand (MAFBNZ) awarded this contract to AsureQuality (then AgriQuality) Limited in collaboration with Avivet Ltd in May 2007.

The comparative assessment covered the welfare of brown layer hens in cage systems, barn systems and free range systems. There are no white egg layers in non-cage systems in New Zealand, so these were excluded from the assessment. MAFBNZ required that organic free range systems be assessed separately to standard free range systems. Data were collected on farm-level variables and bird-level variables affecting hen welfare, taking account of both the biological function and feelings approaches to animal welfare assessment (Duncan, 2005).

Avivet Limited registered specialist in avian medicine Neil Christensen and AsureQuality veterinary epidemiologist Robert Sanson led the survey design and analysis. AsureQuality submitted a summary of the training programme provided for staff involved in performing the assessments to be approved by MAFBNZ. AsureQuality staff were trained to collect the data during farmer interviews, and to carry out environmental and laying hen examinations.

Two farm assessment visits were to be made to each farm, the first soon after peak lay and the second using the same flock of birds in mid to late lay. As it was not practical to attempt to catch the same individual barn or free range birds for the second assessment, individual cages used for the first assessment were not identified in cage houses either.

It was intended that the assessment provide information on comparative production levels and the economics of production for each system, together with environmental parameters relevant to the health and welfare of birds in each system. The survey design was drafted in consultation with MAFBNZ, and was to be outcome (i.e. bird welfare) based.

The scientific approach to the survey was based on international peer reviewed publications, mainly –

Tauson R, Kjaer J, Maria G, Cepero R, and Holm K.-E. *Applied scoring of integument and health in laying hens*. Proc. 7th Symposium on Poultry Welfare, Lublin – A Witkjowski edit. in: Animal Science Papers and Reports 23 supplement 1: 153-159. Institute of Genetics and Animal Breeding, Jastrzębiec, Poland. 2005. (The Tauson or Swedish System)

Weeks C, Nicol C, LayWel, *Welfare implications of changes in productions systems for laying hens*. University of Bristol report to the European Commission, 2006. (The LayWel Study)

3. Materials and Methods

3.1. SELECTION OF FARMS

AsureQuality and Avivet Ltd collaborated with the Egg Producers Federation of New Zealand (EPF), to identify farmers with qualifying flocks in each of the production systems, and who were willing to participate in this study. In addition to the cage, free range and organic categories required by MAFBNZ, the study separated cage and free range systems into larger farms (above 30,000 birds for cages and 3,500 birds for free range), and smaller farms below these figures. The farms were selected to represent the geographical spread of egg production in New Zealand, and care was taken to include a balance of the two main breeds of brown layer on New Zealand layer farms, and representation of all the major suppliers of equipment.

3.2. DEVELOPMENT OF SURVEY METHODS

MAFBNZ provided via the contract documentation basic guidance that the assessment methods used were to be based on internationally-recognised standards of welfare assessment. The terms of reference for the survey required the investigators to include the main breeds used for table egg production in New Zealand. In consultation with MAFBNZ, AsureQuality developed the following assessment tools:

- Questionnaire 1: A standardised questionnaire to collect detailed information covering overall farm management practices. This questionnaire is reproduced as Appendix 1.
- Questionnaire 2: A second questionnaire covering the history and management of the flock being assessed, reproduced as Appendix 2.
- Questionnaire 3: A physical condition scoring tool (Appendix 3) based on published methods. (Tauson and others 2005). Further detail on this questionnaire is provided below.
- Questionnaire 4: On-farm behaviour assessment tools based on those proposed by the LayWel Project. (figures 1 and 2 in the text).

Questionnaires 1 and 3 were applicable to all systems of production, but two separate assessments were developed for questionnaires 2 and 4, one for use in cage flocks and the second for use in barn and free range flocks.

3.3. PHYSICAL CONDITION SCORING

The published methods of Tauson et al (2005) were used without modification. Birds were given scores of 1 (worst) to 4 (best) for plumage condition on six body parts (tail, vent, wings, neck, keel and back), for wounds on comb, body and around the vent, and the state of fleshing of the keel, and for lesions to the feet, (bumblefoot, hyperkeratosis). The system can be used to compare scores for individual body parts or pooled for whole-of-body scores (see www.livsmedelssverige.org/hona/scoringsystem). Birds were weighed using a Salter 5kg dial scale with 20g increments. The birds were suspended by their legs. 30-32 birds were weighed at each visit. In the cage systems, cages on lowest, 2nd and 3rd tiers from the floor were included; all the birds in a cage were weighed, in accordance with commercial practice. This is to ensure that any very underweight or overweight birds were included in the sample (Shaver 2000). In free range and barn systems a portable catching pen was used to pen the birds. During the physical assessment each bird was assessed as being in-lay or not in-lay by measuring the number of fingers the assessor could place between the bird's pin bones (two or more fingers indicated that the bird was in lay; if there was doubt the condition of the

bird's vent and comb was examined). During the physical assessment, the presence of red mites (*Dermanyssus gallinae*), Northern fowl mite (*Ornithonyssus sylviarum*) and lice were assessed by examination of the vent and the feather tracts around the head and under the wings.

Although the mechanics of the scoring followed the Tauson system, the interpretation of the results of bird weights is not straightforward. All primary breeders of layer hens produce a guidebook in which the recommended rearing weights (to achieve optimum production) up to 18 weeks are set out, together with a guide to the target weights at any given age for birds in production. The two major breeds used in New Zealand, Hyline and Shaver recommend different weights for their birds, with the recommended weight for Shaver birds being 15g heavier at 32 weeks and 50g heavier at 62 weeks than the recommended weight for Hyline birds. These were the average ages of the two samples in this survey. Similar guidelines for the Ranger bird, used by 4 organic free range farms were not available, but the genetics of this bird would suggest that its target weight should be 200g greater than the international hybrids. These problems were resolved by calculating the average of the breeders' standard weights for the ages of assessed flocks, and then analysing the weight variation above or below the breeders' standard for any particular age.

3.4. BEHAVIOUR ASSESSMENT

3.4.1 Cage behaviour scoring

The cage behaviour assessment system (figure 1) entailed the observer standing opposite the junction of two cages as shown below ("left hand" and "right hand" in Figure 1) and recording the reaction of the birds to the observer. Birds were assessed according to the LayWel (2006) scheme, section 3.2 as CF (continue feeding), LU (looking up i.e. heads through the bars but not feeding), WH (withdrawn heads inside the bars) and BC (back of the cage). Aggressive pecks and interactions were separately reported. In the analysis of the data CF and LU scores were combined as a positive reaction, those with heads withdrawn were neutral and those at the back of the cage were classified as an aversion reaction. The birds were scored at the arrival of the observer opposite the observation cages, then after 2 minutes and again after 4 minutes. The session was repeated in three to five locations in the house, depending on the number of tiers containing target-flock birds and the number of birds per cage. The average observer could see into 3 tiers of cages. Aggressive interactions – pecking – were counted for the entire 4 minutes over the total number of cages under observation. At an average of 6 birds per cage, and observing two adjacent cages in each tier, there are 36 observations at each site at each of 0, 2 and 4 minutes, involving on average 108 birds. Results are shown in table 32.

Figure 1: Cage layer behaviour assessment sheet

Time	Tier	Left hand cages				Right hand cages				Ag
		CF	LU	WH	BC	CF	LU	WH	BC	
T0	3									
	2									
	bottom									
T 2 mins	3									
	2									
	bottom									
T 4 mins	3									
	2									
	bottom									
Positive		Neutral			Aversion			Aggressive		

3.4.2 Behaviour assessment in non-cage systems

As this was a comparative study between different systems of production, a comparable scoring system for the free range and barn situation was developed using the LayWel behaviour assessment chart (Section 3.6) as a starting point:

Section 3.6

Fly away (very fearful)
Walk away (fearful)
Approach you
Peck at boots

The LayWel charts are intended for repeated use at regular intervals by farm staff. They proved impractical to implement as they did not cover the full range of behaviours that hens in free range and barn systems exhibited. In addition to the above four behaviours, birds were commonly involved in dust bathing, feeding, drinking, wandering around pecking at the litter and occasionally pecking at one another in either an exploratory or an aggressive manner. Some birds would crouch down in front of the assessor in mating pose, but the most common reaction was to ignore the observer completely. Hence the behaviours shown below in figure 2 were recorded:

Figure 2: Behaviour types assessed in non cage birds

Behaviour	No. Birds	Behaviour	No. Birds
Birds working litter		Approach	
Drinking		Peck at boots	
Feeding		Crouch	
Ignore		Fly away	
Aggressive pecking		Walk away	
Positive		Neutral	
		Aversion	
		Aggressive	

In free range and barn systems the behavioural assessment was carried out on a variable numbers of birds within easy-assessable distance. The numbers assessed ranged between 28 and 205 birds. Results are shown in table 33.

3.4.3 Faecal sampling for helminth eggs and coccidian oocysts.

20 to 25 individual fresh droppings, including caecal droppings were collected from each free range (including organic) and barn flock. The samples were examined by floatation using a modified McMaster technique for helminth eggs and coccidian oocysts. In free range flocks some samples were collected inside and some outside. Samples were collected in snap lock bags. On receipt they were weighed and thoroughly mixed with an equal volume of tap water, and left in the refrigerator overnight. The following morning the samples were remixed and a 2.5g aliquot removed. This was mixed with a 17.5ml of saturated sugar- salt solution (SG 1.22), in which sucrose (sugar) replaced glucose in the method of Henriksen and Christensen (1992). The mixture was placed in a McMaster slide counting chamber and examined under 100 x magnification after allowing 3-5 minutes for floatation of eggs and oocysts to occur.

Nematode eggs were recorded as “ascarids” or *Capillaria* spp. Occasional hexacanth embryos characteristic of cestodes were seen. Coccidian oocysts were recorded as *Eimeria acervulina*, *E tenella* and *E maxima*. *E tenella* and *E maxima* were separated using standard criteria (Conway and McKenzie 1991), whilst all oocysts with a length less than 20µm were recorded as *E acervulina*. Results are shown in table 28.

3.4.4 Faecal sampling for corticosterone measurement.

This was carried out on five farms where both free range and cage birds were present, the feed was of common origin and the overall management outlook similar. Faecal corticosterone concentrations provide an integrated measure of plasma corticosterone concentrations over a period of several hours in duration (Fraisse and Cockrem 2006), thus providing an indicator of response to longer term social or physical stress than could be achieved by collecting blood samples for plasma corticosterone analysis. Three subsamples each consisting of 20 fresh faecal droppings were collected from the free range and from the cage flocks on the 5 farms. The process was repeated at the second visit. In the free range systems one sample was collected inside the house and one outside and the third was a mixed sample. In cage systems separate samples were collected from the belts of lowest, 2nd and 3rd tiers, when target flocks were housed in all three tiers. The freshness of the samples was monitored by checking that each was at least 2oC above the temperature of most droppings on the belts using an infra-red laser thermometer (Blue Gizmo BG42). Samples were frozen on dry ice and maintained frozen (less than -20oC) until all samples had been collected. Long term storage was at -70oC. The two cage and two free range groups were analysed as a single batch for the presence of faecal corticosterone at Massey University using the method described by Fraisse and Cockrem (2006). Results are shown in tables 34 and 35.

3.4.5 Production and Mortality Assessment

Meeting market demands for high quality eggs in the size 6 and size 7 range requires farms to have an ongoing programme of flock replacement, in which older flocks reaching the end of their economic life (when eggs are overlarge and have poorer shells) are replaced by younger pullet flocks at point of lay. This means that in any house on most cage-layer farms the birds will be of mixed ages. The costs of automatic egg collection and counters means that few of these farms monitor production by flock or even by house, as the eggs are counted only as they enter the grading room. Farmers record a farm average production, and keep an eye on

each new flock as it enters production to ensure that it is meeting the breeders' standard production target. In some cases a special hand count or single collect is done from a sample of birds as an individual flock reaches peak production. In these cases the authors have allocated standard production to these farms, or such higher or lower production as the farmer records in these individual samples. These constraints on gathering of data restricted the production records to the following:

- Age of flock at 5% production (weeks)
- Peak egg production (hen day % production – the number of eggs/ number of hens)
- Age at peak production (weeks)
- Number of weeks above 90% production
- Number of weeks above 85% production

In free range and barn systems where flocks are single age, comprehensive production records were more likely to be available for the individual flocks monitored, but to maintain comparability with cage flocks the same measures of production were calculated.

Similar constraints applied to the measurement of feed consumption. Most farmers know how much feed they buy, and an approximate daily feed consumption can be calculated. In the minority of flocks where more detailed records of feed consumption were available, these were recorded.

In the case of mortalities in lay, more farmers kept records by flock within cage houses, but some recorded deaths in lay by house. Again, in the barn and free range situation individual flock records were more likely to be available. In the survey, deaths were recorded up to the time of the second visit.

3.4.6 Economic analysis of production

It was originally anticipated that farmers might be comfortable to supply feed cost figures within \$50 bands to avoid compromising commercially sensitive information, but as events unfolded over the nine months that the survey was running, feed prices have risen by 20-40 percent making comparisons between farms within the 3-4 month period of each round of the survey impossible. We have therefore included specimen feed costs from major feed suppliers for their standard feeds over the period of the survey to illustrate these difficulties.

3.4.7 Analysis of data

The data was imported into Microsoft Access for initial data manipulation prior to analysis. A range of univariate and multivariable analyses were conducted using the R (Ihaka and Gentleman 1996) Program for statistical computing, and NCSS, searching for statistical differences between production systems. In addition, the survey examined a number of production and husbandry variables. These results are presented using standard descriptive statistical measures. Categorical data was summarised in frequency tables and where required Chi square, Mantel Haenszel and Kruskal Wallis tests were applied to test for significant differences between production systems. Continuous data was plotted using scatterplots, box and whisker plots and histograms. Some of the box and whisker plots are included in the body of this document.

For the purpose of analysis the variable "Flock type" was divided into 6 levels as defined elsewhere ("B"= Barn housed, "LC"= large-cage flock, "SC"= small-cage flock, "SFR"= small-free range, "OFR"=organic free-range and "LFR"= Large-free range). Contrasts were set, and other flock types were generally compared to a reference level of the LC value

(unless stated otherwise). Confidence intervals were calculated using the “confint” function in R.

Logistic regression models were developed for each of the Tauson scoring response variables; Keel, Feet, Integument and Wounds. These were run using the “glm” function in R. Dichotomous variables were created from the Tauson Scores to facilitate model fitting as the distributions of the ordinal score variables were not normally distributed or easily transformed. Individual score values (1 – 4) were assessed separate to these models using frequency tables and Chi square tests. The observed results were compared to the calculated expected values to identify significant variations.

Linear models were applied to data that approximated a normal distribution. Models were tested for significance using the Wald test from the “lmtest” R library and robust variances were estimated using a sandwich covariance matrix with the “coeftest” function from the sandwich R library.

Categorical values for behaviour was analysed using a multinomial regression. The response variable had three levels; positive behaviour, neutral behaviour and aversion behaviour.

Explanatory variables presented to the models to assess significance were “flock type” (as described above), “visit number” (Visit 1 or Visit 2), beak-trimmed (0= not trimmed, 1 = trimmed) and investigator (a categorical variable representing the inspectors that carried out the field visits).

“Goodness of fit” of models was assessed by use of the Wald test, calculation of the correlation coefficient or comparison of the null model using the deviation and the residuals were examined graphically.

4. Results

Layer hen farmers were very co-operative in both rounds of data collection, and most showed a high level of interest in the work. The farms were spread across most geographical areas of New Zealand and used the two main breeds of brown layer available here: Hyline and Shaver hens; four organic free range properties used the Ranger breed, supplied by Ranger Breeding Co, Kaikohe.

60 farms were visited as below:

- 12 large cage operations (>30,000 birds)
- 13 small cage operations (<30,000 birds)
- 5 barn system operations
- 10 small free range operations (<3500 birds)
- 10 large free range operations (>3500 birds)
- 10 organic farm operations. These are also free range

Five of the free range operations were closely associated, on the same farm properties, with cage layer farms (four farms were large cage, large free range, one was small cage, small free range). These were used for the collection of faecal samples for faecal corticosterone analysis.

The results of the survey of farm management practice and facilities provided for the hens are shown in tables 1 to 17. The type of farm and number of birds included in the survey is shown in table 1 and the distribution of birds on these farms by breed/strain in table 2.

Table 1: Farms included in the survey by production type

Production System	No. farms	Average No. hens	Smallest	Largest
Large cage	12	129,500	30,000	452,000
Small Cage	13	12,863	1,800	28,000
Large free range	10	11,120	4,000	47,000
Small FR	10	1,338	330	3,400
Organic FR	10	3,200	1,600	7,500
Barn	5	18,740	5,600	54,000
Total	60			

Table 2: Total numbers of laying birds on farms included in the survey by breed

Bird Breed	No. Birds on assessed farms
Shaver Brown	1,328,440
Hyline Brown	613,320
Shaver White	149,600
Hyline White	56,500
Other	8,700
Total	2,140,000

This distribution reflects the preponderance of Shaver birds on some of country's largest farms. As free range and organic producers farm only brown laying birds, white laying birds were excluded from the this survey, which therefore is representative of the 1.95 million brown laying birds on the assessed farms.

4.1. AGE RANGE OF BIRDS ON FARMS SURVEYED

The 1.95 million brown laying birds on the farms surveyed were mainly distributed evenly between the ages of 18 to 80 weeks, but included 62,000 birds in excess of 80 weeks.

4.2. CULLING PRACTICES

The low value of end of lay hens and the high compliance costs of operating a processing plant for these birds makes the disposal of end of lay hens a problem for producers; these difficulties could lead to animal welfare problems when flocks are culled. The survey examined age at depletion and the methods employed; the results are shown in table 3:

Table 3: Age of depletion of layer flocks and methods of disposal used

Production type	No. farms	Age@ depletion		No. of farms using method of disposal					
		Mean	Max	Manual neck dislocation	Axe	Gas	Chook buster	Commer slaughter	Sold Live
Large Cage	12	80	85	4	0	2	1	6	1
Small Cage	13	79	82	7	0	0	0	5	5
Large FR	10	81	100	5	0	0	0	4	2
Small FR	10	93	120	3	2	0	0	0	4
Organic	10	82	100	2	0	0	1	6	4
Barn	5	79	80	4	0	0	0	1	2

A number of farms utilised more than one method of disposal. On those farms where some birds were reported as being sold live, the numbers of birds sold, mainly in groups of less than 12 birds to backyard operations, was very small, rarely approaching 10 percent of a flock at depletion.

4.3. MOULTING

Moulting is discouraged by the Code. Only 4 farms stated that they currently moulted flocks, as shown in table 4. All were free range.

Table 4: Farms admitting to moulting birds

Production system	No. farms	Farms practising moulting
Large Cage	12	0
Small Cage	14	0
Large FR	10	2
Small FR	8	1
Organic	10	1
Barn	5	0

Moulting is carried out routinely on a small minority of farms; occasionally flocks are moulted if production has fallen due to disease or feed problems. The use of moulting under these emergency circumstances, usually by free range operators, may be more common than these figures suggest when viewed over a two to three year historical time horizon.

4.4. FEEDING AND REARING PRACTICES

Table 5: Feeding practices employed by the 60 farms surveyed

Production system	No. farms	Feed Source		Feed type during lay		
		Commercial	Home mill	Mash	Pellets	Crumble
Large Cage	12	8	4	12	0	0
Small Cage	13	7	6	9	1	3
Large FR	10	7	3	4	3	3
Small FR	10	7	3	4	6	0
Organic	10	9	1	4	6	0
Barn	5	5	0	1	1	3

Table 6: Rearing practices employed by the 60 farms surveyed

Production system	No. farms	Rearing site		Age at move	Rearing method	
		Rearer	Home	Mean (range) wks	Cage	Floor
Large Cage	12	6	8*	17.1 (16-18)	11	2**
Small Cage	13	2	11	15.1 (5-20)	9	5**
Large FR	10	7	3	17.2 (7-30)	0	10
Small FR	10	6	4	14.8 (8-20)	3	7
Organic	10	8	3*	13.8 (8-16)	0	10
Barn	5	2	3	16.3 (15-18)	0	5

* one farm in each group uses home rearing and a commercial rearer

** one farm in each group uses both cage and floor rearing

The availability of commercial pullet rearing services has expanded in recent years, particularly to service the needs of free range producers. Some farms use the services of pullet rearers for brooding only, and transfer the birds from 5 weeks onwards. The small cage farms stand out as being a group that follows the traditional pattern of rearing birds on the production farm. This group is also the major user of home milling of feed.

4.5. WEIGHING OF BIRDS

Weighing of birds is carried out during rearing to ensure that the birds' weights are in line with breeder targets. Weighing of birds during rearing and lay is stipulated as mandatory in Minimum Standard 2 in the Code. The survey examined the prevalence of weighing birds, and whether they were bulk weighed (a group of birds placed in cage and weighed together) or each bird weighed individually.

Table 7: Weighing practices during rearing on farms where birds are reared on-site

Production system	No. farms	No. home rearing	No. Farms weighing	Birds weighed mean (range)
Large Cage	12	8	4	75 (20-200)
Small Cage	13	11	6	35 (5-100)
Large FR	10	3	2	35 (5-65)
Small FR	10	4	1	ns
Organic	10	3	1	10
Barn	5	3	1	50

Table 8: Weighing practices during lay

Production system	No. farms	No. bulk weighing	Birds weighed mean (range)	No individual weighing	Birds weighed mean (range)
Large Cage	12	4	35 (20-50)	3	35 (5-60)
Small Cage	13	1	ns	3	15 (6-20)
Large FR	10	1	30	5	15 (6-30)
Small FR	10	1	ns	0	-
Organic	10	1	10	1	45
Barn	5	1	24	1	10

ns = not stated

Individual weighing allows the rearer to accurately estimate uniformity within the flock, while bulk weighing allows feed rates to be adjusted according to bird weight. Since the advent of lighter brown hybrids in the mid 1990s, restricting bird weight during rearing has become much less important than with the heavier brown birds in use previously.

The same applies to weighing during the production phase. Birds' appetites are much smaller than they used to be, and underweight flocks are as much an issue as overweight ones in modern egg production farms. The survey did not ask how often the birds were weighed, but in the most cases where weighing was done it was stated that it was done infrequently. The limited use of weighing of birds should be viewed together with the results of the individual bird weighing carried out during this survey, which indicate that any negative effects of this low use of bird weighing on bird welfare in modern light hybrids are minimal.

4.6. BEAK TRIMMING

Table 9: Beak Trimming Practices

Production system	No. farms	Not beak trimmed	Cautery	Laser beak trimming
Large Cage	12	3	0	9
Small Cage	13	1	3	9
Large FR	10	0	1	9
Small FR	10	2	3	5
Organic	10	6	0	4
Barn	5	0	2	3

The introduction by both major hatcheries in 2006 of laser beak trimming using a machine produced by the Novatec Company from the USA has resulted in major changes in beak

trimming practices, with the adoption of laser beak trimming by farms that previously did not trim birds' beaks, and by those that used cautery. At the time of this survey, the use of cautery was in decline.

4.7. FACILITIES AND EQUIPMENT AVAILABLE TO HENS

Table 10: Cage types and manufacturers used by assessed birds

Production system	No. farms	BD	SAL	FA	FT	CM	OF
Large Cage	12	4	4	2	2	0	0
Small Cage	13	0	3	3	2	2	4

BD = Big Dutchman SAL = Salmat FA = Farmer Automatic
 FT = Farmtec CM = Cagemaster OF = Old fashioned

The figures in Table 10 show the cage manufacturers supplying the equipment used to house the birds actually assessed during the current project. They show that equipment from a wide selection of manufacturers was included in the survey. A number of farms used equipment supplied by more than one manufacturer. In the case of the old-fashioned cages, a number of means of converting these cages have been adopted. These included combining cages and/or reducing the number of birds from three to two.

Table 11: Equipment manufacturers used by Barn, Free range and Organic free range egg producers

Production system	No. farms	Vencomatic	Jansen	FA	BD	Manual
Large FR	10	4	2	1	1	2
Small FR	10	0	0	0	0	10
Organic	10	0	0	0	0	10
Barn	5	3	1	0	0	1

BD = Big Dutchman FA = Farmer Automatic

Tables 10 and 11 indicate that a wide variety of equipment manufacturers were used to house flocks included in the survey. Although produced by a range of international manufacturers, the cage systems showed minimal variability. Free Range and barn producers used a wide variety of facilities as is shown in table 12 below. The differences between the small free range farms and the large ones was most marked in the facilities in use; the free range farms with highest hen density were small flocks using movable facilities that the birds used only to sleep in, and for access to nest boxes, rather than to live in most of the time.

Table 12: Production facilities employed in free range and barn egg houses

Production system	No. farms	Shed area m ² (range)	Area: bird/m ² (range)	Std Dev	Winter garden	M	C	E	C+E
Large FR	10	419 (825-100)	9.1 (12.7 -7.4)	1.6	7	0	8	2	0
Small FR	10	49 (171-15)	8.5 (21.2 - 2.0)	6.1	2	4	4	1	1
Organic FR	10	113 (36-270)	7.4 (16.7 - 5.0)	3.6	4	2	6	2	0
Barn	5	463 (840-180)	7.3 (9.4 -5.5)	1.6	n/a	0	4	0	1

M = movable C= Concrete floor E = Earth floor C+E partly earth and partly concrete floor

The Code provides for maximum bird densities of 7 birds/m² in barn operations and 10 birds/m² in free range operations. The average density of birds in the barn operations was slightly over that provided for in the Code. In the case of free range operations, the average densities across the flocks surveyed was within the Code allowances; however there is a wide variation in the stocking densities of the free range sheds surveyed. This reflects the two approaches to housing free range flocks, which the Code does not currently take into account. There are those flocks where the birds live outside and enter the sheds to sleep and to lay eggs – this is especially the case on farms using movable sheds; then there are those flocks that live largely indoors and spend a variable, but often small, part of their day outside. The houses for the former group, especially movable houses, are generally small and, by the standards of the Code, overstocked. The Code should be modified to reflect this duality.

A wintergarden is a porch, usually running the length of the side or end of a house that is partly enclosed with wire. It often contains extra drinkers, which helps to keep the interior of the house dry. It provides shelter for the birds, and eases pressure on pop holes.

All the commercially-manufactured free range and barn systems incorporated a partly slatted floor covering half to two-thirds of the floor area in their design. The litter area was covered in shavings, sand or sawdust. Slatted areas were present in a minority of the manual systems. Shavings were the main litter substrate used in manual non-slatted systems.

4.8. ELECTRIFIED WIRE USE

The correct use of an electrified wire situated under the feed trough to prevent birds from pecking eggs is allowed under Minimum Standard 5 of the Code. The installation of electrified wires was not widespread in the sample of farms surveyed. One farm in each group reported problems with the hot wires, and two of the three small cage farms with the wires installed did not use them.

Table 13: Use of electrified wire to discourage birds from damaging eggs

Production system	No. farms	Sheds with Hot Wire Installed	Hot Wire used	Problems reported
Large Cage	12	4	4	1
Small Cage	13	3	1	1

Two large free range and one barn egg farm had electrified wires along the walls to discourage birds from floor laying.

4.9. NEST BOX PROVISION

Table 14: Provision of nest boxes

Production system	No. farms	Farms with individual nests	Birds per nest (<i>STDEV</i>), Range	Farms with communal nests	Birds per metre (<i>STDEV</i>) Range
Large FR	10	3	10.6 (4.1) 6-14	7	65 (17) 36-84
Small FR	10	9	8.2 (4.1) 3-13	1	NS
Organic FR	10	9	9.0 (2.5) 7-14	1	50
Barn	5	0		5	41 (5) 35-48

NS in the single SFR farm with communal nests, the number of birds per nest was not stated.

The Code recommends (section 3.3.4) as best practice a maximum 7 birds per nest. The average number of birds per nest for flocks in this survey exceeds this recommendation for all 3 sub-groups of free range farms with individual nests.

In the case of communal nests, the Code (section 3.3.4) recommends provision of nesting space to a maximum of 120 birds/m². Most farms with automatic nests view their nest boxes as linearly-measured facility. In general, allowing for a width of nest box systems of 0.5m, the majority of communal nest box systems installed comply with the recommended best practice set out in the Code.

Table 15: Nest box substrate

Production system	No. farms	Shavings	Mat/carpet	Straw	Other
Large FR	10		10		
Small FR	10	3	4	3	
Organic FR	10	2	7		Liners1, plastic1
Barn	5		5		

The usage of mats and carpets is widespread in manual systems, in addition to the automated systems designed solely for use with mats. Matting substrates that can be removed and cleaned have advantages in areas of egg hygiene and labour saving compared to shavings. No adverse welfare outcomes from their use could be determined during this survey.

4.10. OUTSIDE PROVISION OF SHELTER IN FREE RANGE SYSTEMS

Shade and shelter is not the subject of a minimum standard in the Code, but recommended best practice is that “Shade and shelter structures in systems providing outside access should be provided for protection and refuge from predators and adverse climatic effects”.

Table 16: Provision of shelter

Production system	No. farms	None	Trees	Other	Outside water troughs
Large FR	10	6	4	0	0
Small FR	10	3	6	Hedge 1	3
Organic FR	10	1	7	Kiwifruit canopy 1 Hedge 1	1

It is apparent that in the sample of farms surveyed, the larger free range properties were less likely to provide shelter than were the smaller free range and organic farms. A number of producers commented on the fact that birds that spent most time outside showed deeper development of comb colour.

4.11. PREDATION

The survey examined the incidence of predation on the free range and organic farms.

Table 17: Free range farms reporting problems with predation

Production system	No. farms	No problems reported	Farms reporting problems with		
			Hawks	Stoats	Other
Large FR	10	2	7	0	Seagulls 1
Small FR	10	3	3	3	
Organic FR	10	1	8		Magpies 1 Feral cats 1

4.12. RANGE AREA AVAILABLE TO FREE RANGE BIRDS

No data were specifically collected on range areas, but assessors noted that this varied from a run about the size of a tennis court up to a 20 hectare paddock, with all variations in between. The numbers of paddocks available for rotation varied from one to eight. All range and shed access areas were assessed as having adequate drainage. A few farms had puddles, the presence of which was dependent on the weather.

The issue of range available to birds was raised by a number of smaller free range farmers, who believed that large scale free range operations, in which birds had access to limited range in relation to their numbers was somehow inimical to birds welfare.

In many cases the range area available to birds, especially near the sheds was bare, or the vegetation present was made up largely of weeds. The incidence of reported poisoning due to weed ingestion is low.

4.13. ASSESSING BIRD'S WEIGHTS AND PHYSICAL CONDITION

The interpretation of bird weights collected in this study is not as straightforward as the authors of the Tauson scoring system would have us believe for the following reasons. All primary breeders of poultry supply producers with a guidebook in which the recommended rearing weights (to achieve optimum production) up to 18 weeks are set out, together with a guide to the target weights for birds in production. The two major breeds used in New Zealand, Hyline and Shaver have different recommended weights. The recommended weight for the Shaver bird is 15g heavier at 32 weeks and 50g heavier at 62 weeks than the recommended weight for Hyline birds. These were the average ages of the birds in the two samples in this survey. Similar guidelines for the Ranger bird, used by 4 organic free range farms were not available, but the genetics of this bird suggest that its target weight should be at least 200g greater than the weight of the two international breeds.

These problems have been resolved by calculating the average of the breeder standard weights for the ages of assessed flocks, and then analysing the weight variation above or below the breeder standard for any particular age.

The results of the assessment of birds' weights and physical condition is shown in table 18 for the first round of farm visits and table 19 for the second round. One of the large free range flocks was removed from the second assessment, as it had been removed to another farm and moulted, reportedly as a result of an outbreak of histomoniasis (blackhead). This accounted for the fall in number of birds assessed in the second round of visits.

Table 18: Tauson scores of physical condition of birds assessed at the first visit (32 weeks of age)

Management System	No. Birds assessed	Avg Age (wks)	Breeder Std Weight (g)	Avg Weight (g)	Variation from std (g)	Std Dev (g)	%. birds in lay	Tauson Score (1-4) Average			
								Keel	Feet	Integument	Wounds
All systems	1805	32	1907	1942	35	206	95.2	3.0	3.9	3.6	3.90
Large cage	362	31	1890	1896	6	201	98.8	2.9	3.8	3.6	3.98
Small cage	390	33	1902	1955	53	220	99.8	3.0	3.9	3.4	3.93
Large FR	300	31	1902	1910	8	169	98.8	3.0	3.9	3.7	3.90
Small FR	300	29	1873	1902	29	201	92.2	2.8	3.9	3.6	3.99
Organic	303	36	1976	2013	37	197	92.7	3.2	3.8	3.4	3.84
Barn	150	32	1907	1948	41	210	96.6	2.9	3.9	3.8	3.98

Table 19 Tauson scores of physical condition of birds assessed at the second visit (62 weeks of age)

Management System	No. Birds assessed	Avg Age (wks)	Breeder Std Weight (g)	Avg Weight (g)	Variation from std (g)	Std Dev (g)	% birds in lay	Tauson Score (1-4) Average			
								Keel	Feet	Integument	Wounds
All systems	1773	62	1966	1990	24	240	95.3	3.0	3.7	2.94	3.88
Large cage	361	63	1948	1997	49	253	98.0	2.9	3.6	2.6	3.95
Small cage	390	64	1955	1999	44	238	98.5	2.9	3.6	2.5	3.95
Large FR	270	59	1953	1932	-21	221	96.7	3.0	3.8	3.0	3.85
Small FR	300	62	1956	1998	42	219	86.7	3.1	3.7	3.3	3.89
Organic	302	67	2044	2039	-5	254	94.0	3.1	3.8	3.2	3.65
Barn	150	58	1924	1976	52	218	97.3	2.9	3.9	3.4	3.95

4.14. BIRD WEIGHTS

On average the birds' weights were close to the breeders' standards, but the standard deviations both within and between flocks showed a large variation. The organic free range birds, which included the Ranger flocks were not surprisingly the heaviest group of birds, but also showed the greatest variation in within-flock weights. The variability of bird weights increased from the first to second round of scoring. Variability was marginally higher in free range samples, including organic free range flocks, than amongst the samples from birds housed in cages. Although the data was not collected, a number of assessors remarked on the fact that there was frequently one 'backward', light bird in each cage.

Only the small free range flocks showed a significant fall in the number of birds capable of producing eggs at the second visit (see tables 18, 19).

4.15. TAUSON CONDITION SCORING

Table 20: Comparison of Visit 1 and Visit 2 Tauson Mean Scores for Keel, Feet, Integument and Wounds.

Management System	No. Birds assessed		Avg age (wks)		Mean Tauson Score (1-4)							
					Keel		Feet		Integument		Wounds	
	V1	V2	V1	V2	V1	V2	V1	V2	V1	V2	V1	V2
All systems	1805	1773	32	62	3.0	3.0	3.9	3.7	3.6	2.94	3.90	3.88
Large cage	362	361	31	63	2.9	2.9	3.8	3.6	3.6	2.6	3.98	3.95
Small cage	390	390	33	64	3.0	2.9	3.9	3.6	3.4	2.5	3.93	3.95
Large FR	300	270	31	59	3.0	3.0	3.9	3.8	3.7	3.0	3.90	3.85
Small FR	300	300	29	62	2.8	3.1	3.9	3.7	3.6	3.3	3.99	3.89
Organic	303	302	36	67	3.2	3.1	3.8	3.8	3.4	3.2	3.84	3.65
Barn	150	150	32	58	2.9	2.9	3.9	3.9	3.8	3.4	3.98	3.95

4.15.1 Statistical Analysis of Physical Examination (Tauson) Scores

A logistic regression model for each of Keel, Feet, Integument and Wounds scores was developed to assess the effects of flock housing systems, age-related differences (i.e. between inspection rounds 1 and 2) and the effects of beak trimming on these scores. The dichotomous response variable was defined as 1 where an examined bird **had any one score** within the grouping (e.g. one of the wound scores from comb, vent or body) below three, and 0 where the all scores were 3 or greater. Explanatory variables that were available to the models were "type" (flock housing system category with reference level set to LC (large, cage flock), visit number (round 1 or round 2), beak trimmed (1=yes or 0=no) and investigator (number 1 to 5).

Robust variances were estimated using a sandwich covariant matrix so that p value estimates are conservative.

4.15.2 Keel

Table 21: Results of Odds ratios from logistic regression model of keel scores

Variable	Odds ratio Coefficient ^a	lower 95% CI	Upper 95%CI	Pr(> z)
Farm Type				
Reference (LC)	1.00			
Small cage	0.48	0.36	0.64	<0.001
Large FR	0.66	0.50	0.89	0.01
Small FR	0.58	0.43	0.78	<0.001
Organic FR	0.67	0.50	0.89	0.01
Barn	0.63	0.44	0.90	0.01
Visit				
Reference (visit 1)	1.00			
Visit 2	1.75	1.45	2.10	<0.001

^a The co-efficient is the \log_e of the relative effect of farm type on the presence of a keel score of less than 3.

For example, a bird farmed in an organic system is 0.67 times as likely to have a keel score of below 3 as one in a large cage farm. The keel scores reflect ‘fleshing’ - see discussion where the advantages of the Laywel EU scheme are discussed.

4.15.3 Feet

Table 22: Odds ratios of logistic regression of feet scores

Variable	Odds ratio Coefficient ^a	lower 95% CI	Upper 95%CI	Pr(> z)
Farm Type				
Reference (LC)	1.00			
Small cage	0.41	0.25	0.67	<0.001
Large FR	0.24	0.11	0.45	<0.001
Small FR	0.26	0.13	0.48	<0.001
Organic	0.47	0.27	0.78	<0.001
Barn	0.00*	0.00	16.95	<0.001
Visit				
Reference (visit1)	1.00			
Visit 2	4.20	2.71	6.76	<0.001

*The estimate of the odds ratio for “Barn” is zero as there were no values recorded below 3.

^a The co-efficient is the \log_e of the relative effect of farm type and visit on presence of pad, toe or claw lesions on an individual bird of less than 3.

For example, a bird farmed in large free range system is 0.24 times as likely to have a foot lesion leading to a score of below 3 as one in a large cage farm (or a bird on a LC farm is 4X more likely to have such a foot lesion as the bird on the OFR farm). However the visit statistics show that a 62 week old bird is 4.2 times more likely to have a serious foot lesion than a 32 week bird, irrespective of the farming system.

Table 22 should be viewed through the perspective of table 20, which shows that no housing system had an average score for feet below 3.8 (out of a best-possible 4.0) at the first visit and 3.6 at the second visit.

4.15.4 Integument

Integument scores were close to normally distributed so a linear regression was carried out for ease of interpretation.

Table 23: Odds ratios of logistic regression of integument scores Round 2

Variable	Odds ratio Coefficient ^a	lower 95% CI	Upper 95%CI	Pr(> z)
Farm Type				
Reference (LC)	1.00			
Small cage	2.42	1.86	3.16	<0.001
Large FR	0.52	0.39	0.70	<0.001
Small FR	0.23	0.17	0.31	<0.001
Organic	0.41	0.31	0.55	<0.001
Barn	0.18	0.12	0.26	<0.001
Beak treatment				
Ref (beak not trimmed)	1.00			
Beak trimmed	0.66	0.52	0.84	<0.001
Visit				
Reference (visit1)	1.00			
Visit 2	17.10	13.98	21.05	<0.001

^a The co-efficient is the log_e of the relative effect of farm type , beak treatment and age (visit no.) on the presence of a single defeathered area with a score of less than 3.

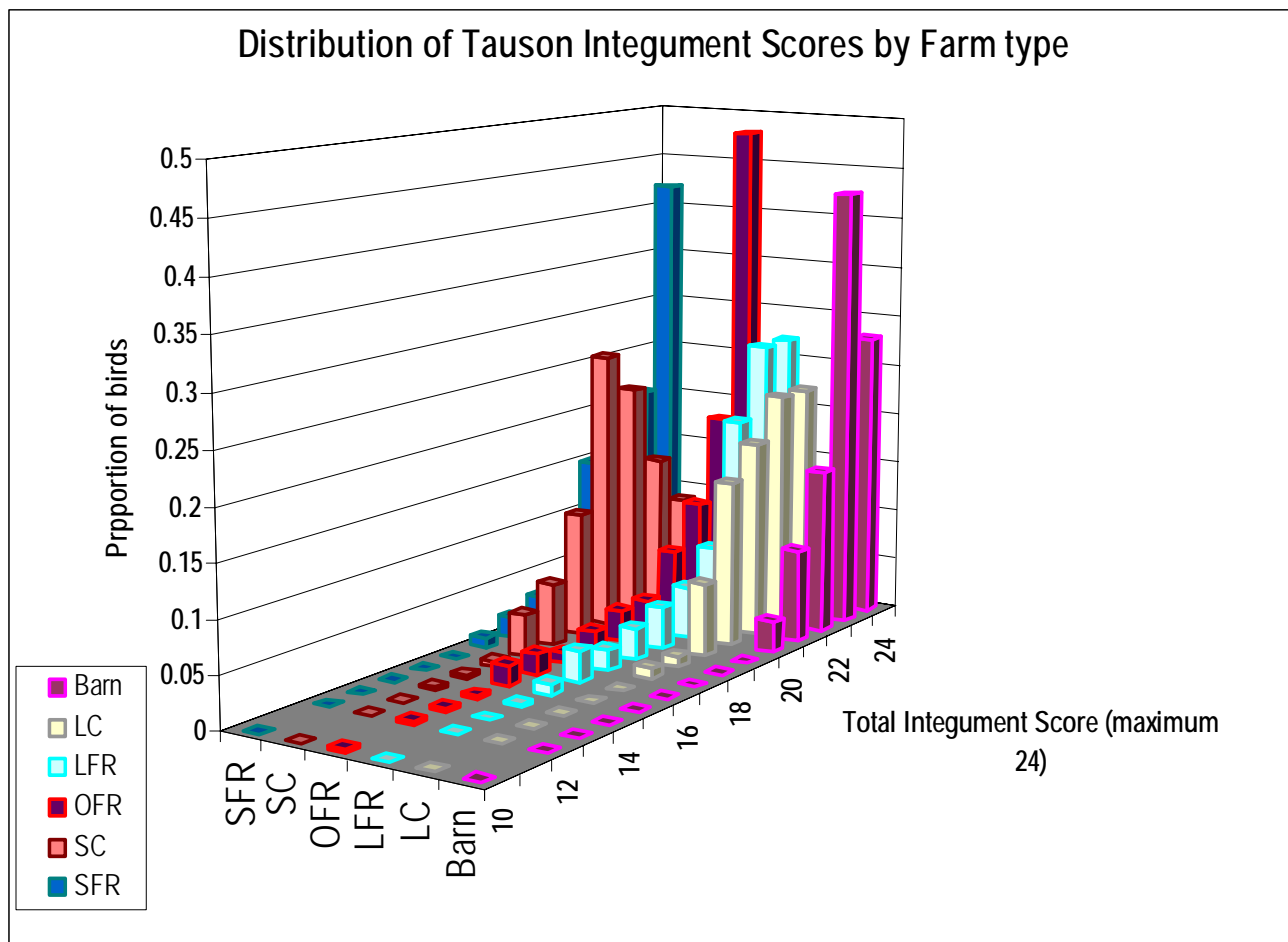
For example, a bird farmed in small cage system is 2.4 times as likely (at the second visit) to have a poorly-feathered part of its integument leading to a score of below 3 as one in a large cage farm. However the visit statistics show that a 62 week old bird is 17 times more likely to have a single defeathered part of its integument than a 32 week bird, irrespective of the farming system, and beak-trimmed birds exhibit only two thirds of the chance of poor feathering (at the second visit) as do non beak-trimmed birds.

There were 12/59 non beak-trimmed flocks at the second visit, 6 of them OFR farms.

Small cage flocks have 2.42 times the odds of an individual integument score lower than 3 when compared to large cage flocks, yet both have a mean score of 3.95. This implies a greater variability in integument condition amongst birds on SC farms.

This form of modelling has simplified the data that has been collected by transforming the response variable into a dichotomous variable and does not show which flocks actually produce the lowest score (poorest feather condition) birds. The data in the 3-dimensional bar graph in figure 3 show the proportion of birds with each total integument score from visit 2. A bird with a “perfect” score of four for each of the six anatomical areas examined would have the maximum score of 24. Birds with a score of above 18 (at 62 weeks) can be considered well feathered. Each of the flat squares in figure 3 representing birds having a Tauson integument score of 14 or less represents only one bird, and (e.g.) 48 percent of birds on OFR farms (the tallest bar) had a “perfect” 24 score.

Figure 3: Distribution of Tauson individual bird average integument scores by farm type



4.15.5 Wounds

Table 24: Odds ratios of logistic regression of wound scores

Variable	Odds ratio Coefficient ^a	lower 95% CI	Upper 95%CI	Pr(> z)
Farm Type				
Reference (LC)	1.00			
Small cage	1.03	0.42	2.55	0.948
Large FR	2.84	1.30	6.58	0.011
Small FR	1.24	0.51	3.06	0.629
Organic	7.15	3.71	15.24	<0.001
Barn	0.00	0.00	124.65	0.980
Beak treatment				
Ref (beak not trimmed)	1.00			
Beak trimmed	0.58	0.36	0.94	0.0272
Visit				
Reference (visit1)	1.00			
Visit 2	4.28	2.72	7.01	<0.001

^a The co-efficient is the log_e of the relative effect of farm type, beak treatment and age (visit no.) on the presence of a single body zone (comb, vent or body) with wounds scoring less than a 3.

For example, table 24 shows that a bird farmed in an organic cage system is 7.15 times as likely to have wounds leading to a score of below 3 as a bird in a large cage farm. However the visit statistics show that an older bird is 4.28 times more likely to have a serious wound than a younger bird, irrespective of the farming system. As would be expected, beak-trimmed birds exhibit only 58 percent of the chance of having a serious wound than do non beak-trimmed birds.

Compared to the reference level (large cage flocks) the following housing systems did not have statistically significant differences in the prevalence of wound scores less than 3: flocks on small cage farms, small free range flocks and barn-housed flocks.

Larger free range flocks showed 2.84 times the likelihood of having a wound scoring less than 3, compared to a large cage farms. This difference was statistically significant $\Pr(>|z|) = 0.011$.

There were no significant differences in the mean Tauson lesion scores for keel fleshing and foot lesions between the types of housing system at the first and second assessment visits, but there was a small numerical deterioration in the condition of the feet of birds housed in small and large cage farms at the second inspection visit. There was a significant deterioration in the integument scores of both groups of cage birds compared to non-cage systems at the second visit. The organic free range birds showed significantly more wounds at the second visit compared to the first, whilst the other free range systems showed a smaller increase in wounds.

The survey did not show a marked reduction in body condition score of birds in any system up to the average age of 62 weeks at the second visit, and allowing for differences in scoring methods, supports the conclusion of Gregory and Devine (1999) that emaciation was not a normal feature of end of lay hens.

The Tauson System is not as useful in assessing welfare outcomes in the case of keels as it is for scoring other parts of the anatomy, because it does not differentiate the welfare implications of poor fleshing around the keel with fractures of the sternum that occur in older birds due to progressive onset of osteoporosis (Whitehead 2003). In cage birds the lack of physical activity increases the predisposition to suffer bone fractures, and in non-cage birds to flying into obstructions increases the incidence. Wilkins *et al* (2004) have provided useful tools for the assessment of this damage. A more useful and practical scheme for the assessment of keelbone status has recently been provided by researchers from the Friedrich Loeffler Institute, Celle, Germany, who modified the LayWel system. In their LayWel-EU modified scheme, keel assessment concentrates on keel damage. This would have been a more useful approach as most of the fleshing measure of the Tauson System is more objectively captured by weighing the birds. It is recommended that keel scores should reflect an assessment of damage to the keel rather than fleshing.

4.16. PRODUCTION AND MORTALITY RATES

Not all farms were able to provide usable data for the assessment of production and mortality rates in lay. Mean production and mortality rates for the six types of farm assessed are shown in Table 26.

Table 25: Mean values for production data by farm type

	Farms with data	Farms visited	Age @ 5% Prod	Peak Lay %	Peak age (wks)	Weeks above 90%	Weeks above 85%	age 2 nd visit (wks)	Mean Mortality to 2 nd visit %
Large cage	7	12	17.9	95.1	27.2	21.9	32.7	63	2.9%
Small cage	7	13	18.0	93.8	27.7	18.4	29.4	64	3.1%
Small FR	7	10	19.8	88.1	29.0	4.7	13.2	64	6.3%
Large FR	8	9	18.7	92.1	29.2	11.0	22.3	59	6.4%
Organic FR	8	10	18.8	89.3	29.0	2.6	9.1	67	7.2%
Barn	5	5	18.5	92.2	28.8	15.5	22.8	58	5.3%
Shaver Std			18	95	26	23	34	60	2.5%
Hyline Std			18	95	28	24	32	60	2.4%

The data for bird age at peak production, peak lay percentage and number of weeks above 85 percent production is also displayed in figure 4. Note that figures 4 and 5 show median figures compared to mean figures in table 25. Mortality data is further analysed in figure 5 and table 26. The red lines indicate the Hyline and Shaver standards at 60 weeks of age. The large free range farms provided the best data on a flock basis with eight out of the nine farms visited in the second round having usable data.

4.16.1 Production

Boxplots in this document show five data summary elements. The solid horizontal line through the centre shows the median value; the extent of the box is set to the upper and lower quartiles (between 25 – 75 percent of data points fall within this interquartile range [IQR]). The small horizontal lines at the end of the whiskers represent the highest and lowest values. Individual values that are greater or less than 1.5 times the IQR from the edge of the box are considered to be outliers and are represented by a small circle or a cross.

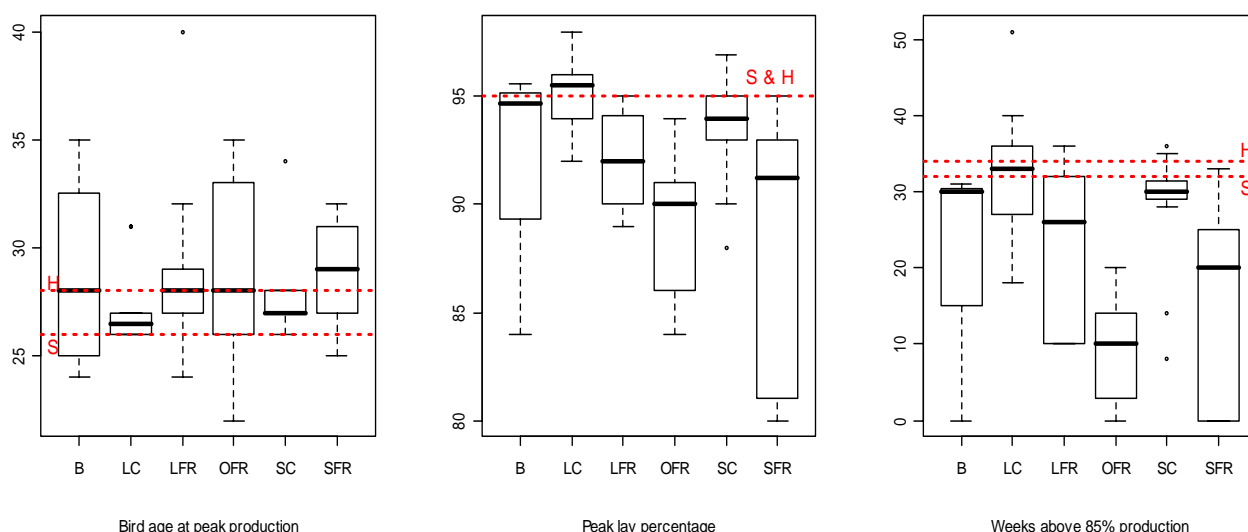


Figure 4: Production measures by flock type (Red lines represent industry standard; S=shaver breed, H=hyline breed)

All measures were tested for significance using the Kruskal Wallis sum rank nonparametric test which does not require normally distributed data, and are illustrated in Fig.4.

Bird age at peak production was not statistically different between the different production systems. However the distribution ranges for all three parameters for cage systems were consistently narrower (tighter) than those of barn and free range farms.

The median peak lay percentage for the large cage category (95.5 percent) was significantly higher than the median peak lay percentage in the free range flocks; OFR, LFR and SFR with p values of <0.001, 0.005, 0.007 respectively. The median peak lay percentage for SC of 94 percent was significantly higher than OFR which peaked at 90 percent (p=0.008). OFR was not significantly different to the other free range categories or barn housed hens. The p value threshold for significance was set at <0.05.

OFR flocks had a median number of “weeks above 85 percent lay” of 10, which was significantly lower than cage systems: LC (median = 33), SC (median = 30)). LC systems had significantly more weeks above 85 percent lay than SFR (median = 20). Both LFR and SFR distributions that were bimodal with a group of farms with lower numbers of weeks above 85 percent lay percentage (hence no lower whisker) and another around the median.

4.16.2 Mortality in Lay

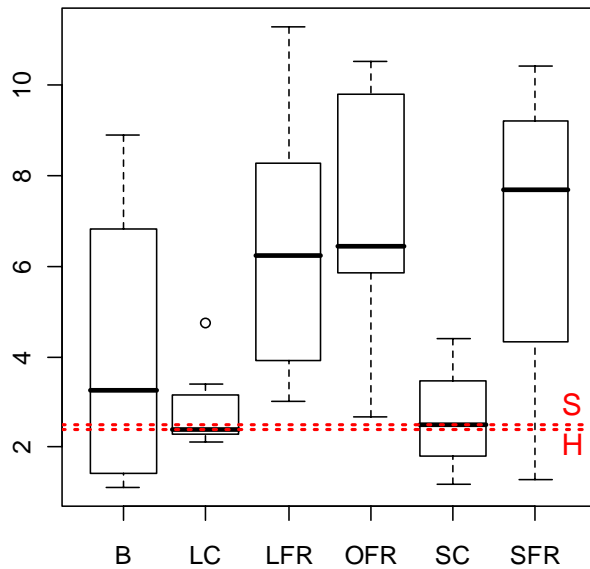


Figure 5: Box and whisker plots of mortality percentage by flock type (Red lines represent industry standard; S=shaver breed, H=hyline breed)

The mortality data was normally distributed so a univariate linear regression model was used to examine the effect of flock management type on mortality. Note that mortality data was not available for all flocks in the study. Large cage flock (LC) Intercept was used as the reference level of the flock type categorical variable for comparison in the model.

Table 26: Univariate linear model for mortality with flock management type as explanatory variable

Variable	Estimate	Std Error	Lower 95% CI	Upper 95%CI	Pr(> z)
Farm Type					
Intercept (LC)	2.88	0.33	0.93	4.82	<0.001
Small cage	-0.22	0.53	-2.97	2.54	0.682
Large FR	3.51	1.00	0.84	6.18	0.001*
Small FR	3.89	1.72	0.66	7.12	0.030 *
Organic	4.30	0.95	1.63	6.97	<0.001*
Barn	1.25	1.57	-1.98	4.48	0.433

* statistically significant difference

There was no statistical difference between LC, barn or SC. Mortality was significantly higher in free range and organic flocks. OFR flocks had an average mortality that was 4.30 percent higher (1.63 – 6.97) than that of large cage flocks. Average mortality percentage in LFR was 3.51 percent higher than the average for large cage flocks. See Table 26 for coefficients and confidence intervals. The correlation coefficient (R^2) was 0.4 (this indicates that 40 percent of the variability in mortality is explained by the flock management type variable).

Production figures in the both large and small cage farms were close to the breeder's guidelines, although recorded mortality for all flock types was higher than breed standards. Free range flocks suffered approximately twice the death rate of the cage flocks. Barn flocks

were intermediate but were not significantly different to either free range or cage flocks. The figures for cage and non-cage systems were similar to those recorded in a recent British report into the comparative welfare of laying hens in cage and non-cage housing systems (Croxall and Emery, ADAS, 2006).

The cage farms in general, and especially the larger ones, showed little variability in their production and mortality levels. There was a greater degree of variability in the production and mortality figures amongst the barn, free range and organic farms. This variability is to be expected given the variability in production methods and, in the case of the organic farms, breed of laying bird involved. The best-performed farms in the large free range and barn groups returned figures very close to those of the cage groups, as can be seen from the interquartile ranges and whisker-bars in Figures 4 and 5.

4.17. FEED CONSUMPTION AND FEED COSTS

Feed consumption data for assessed individual flocks was hard to calculate on many farms; in a very small number of cases a feed consumption figure was available but farmers were unwilling to divulge it, citing commercial sensitivity. Feed consumption varies with density of nutrients in the ration, production level, and ambient temperature, making it difficult to interpret consumption figures outside their individual context.

In the case of feed costs, the survey was undertaken at a time of rapidly rising feed costs. The author approached a major North Island feed supplier and a supplier of organic feed for historical prices for the price of a one-off delivery of 3 tonnes of standard layer feeds. These figures are shown in Table 27.

Table 27: Sample feed costs over the period of the survey

Feed type	Premium layer	"Free Range" Layer	Organic layer
Month	\$/tonne	\$/tonne	\$/tonne
Aug 2007		538	
Sep 2007	552	563	900
Dec 2007	582	628	
Feb 2008	590	685	1000

Bulk and contract purchasers of feed would be expected to pay lower prices, as would those farms with their own feed mills, depending on the price at which they had secured their grain and other ingredient supplies for the season.

4.18. PREVALENCE OF DISEASE AMONGST THE SAMPLE FLOCKS

One LFR flock was withdrawn from the sample as it had been moulted and moved to a different location on the grounds that it had suffered an outbreak of histomoniasis (blackhead). One organic free range flock suffered an outbreak of diarrhoea on which a diagnosis of spirochaetal diarrhoea (*Brachyspira* spp) was returned. Other disease-related information came from faecal egg counts of free range, organic and barn flocks for helminth eggs and coccidian oocysts, and checks for the presence of ectoparasites during the physical examination of the 30 birds per flock.

In the case of the helminth parasites only birds in barn and free range systems were assessed, as the cage systems generally do not provide the faecal-oral transmission pathways required by nematodes commonly present in New Zealand commercial poultry.

Table 28: Faecal helminth egg and coccidian oocyst count recorded on samples collected during the first and second rounds of farm visits

Faecal worm egg/coccidian oocyst count record (first round)								
Farm Type	No	Av Age	Ascarid	Capillaria	Cestode	<i>E acervulina</i>	<i>E tenella</i>	<i>E maxima</i>
		weeks	epg	epg	epg	opg	opg	opg
Large free range	10	31	305	50	0	540	105	0
<i>farms positive</i>			5	4	0	7	1	0
Organic free Range	10	36	710	300	0	1150	0	45
<i>farms positive</i>			8	9	1	8	0	2
Small free range	10	29	335	205	10	1505	20	20
<i>farms positive</i>			7	5	2	8	2	2
Barn	5	32	380	0	0	19860	0	480
<i>farms positive</i>			4	0	0	5	0	2
Faecal worm egg/coccidian oocyst count record (second round)								
Large free range	9	60	244	67	0	200	0	0
<i>farms positive</i>			6	2	0	6	0	0
Organic free range	10	67	805	110	0	145	0	0
<i>farms positive</i>			8	7	0	7	0	0
Small free range	10	57	340	115	0	16450	15	5
<i>farms positive</i>			9	6	0	10	2	1
Barn	5	58	1290	90	0	320	0	10
<i>farms positive</i>			5	2	0	5	0	1

Farms positive = no. of farms in each group with FEC > 49epg/opg

The eggs of *Ascaridia galli* and *Heterakis gallinarum* are very similar in appearance, and were not routinely differentiated, both being recorded as “ascarids”. *A galli* has barrel shaped side walls and is 75-80 μ in length, whilst *H gallinarum* is 63-75 μ in length and has straight side walls (Thienpoint *et al* 1979). In 4 samples from each visit round, the presence of both types of egg was readily distinguishable. In the first round of sampling, organic free range flocks recorded the highest levels of worm egg counts; in the second round the figures remained very similar except that the counts in the barn flocks had risen considerably. This possibly reflects the fact that free range flocks have immediate access to contaminated range, whereas barn flocks are placed in houses that are cleaned between flocks, and the environmental burden of infective worm eggs takes some weeks to rise again in a new flock.

The numbers of eggs in this survey was comparable with the FEC recorded by Janssen Pharmaceutical (Worm Eradication in Poultry) in a European trial involving 21 flocks recorded an average of 636 epg of ascarids (21/21 positive, mainly *A galli*) and 4/21 positive for Capillaria eggs averaging 125epg in the positive flocks and 24epg if averaged over the entire 21 flocks (table 29).

Table 29: Roundworm FEC detected in 21 European layer and breeder flocks

Roundworm species	Flocks positive	FEC (epg)
<i>Ascaridia galli</i>	19	576
<i>Heterakis gallinarum</i>	8	57
<i>Capillaria spp</i>	4	24

The coccidian oocyst counts were uniformly very low. The high *E acervulina* average counts in the first round barn and second round small cage were derived from single farms with 97,500 and 162,000 opg respectively. All other positive samples were below 1000opg, and most below 500opg. To put these counts in perspective, the standard anticoccidial challenge in trials are is 300,000 oocysts of *E acervulina* in young non-immune birds (Conway and McKenzie 1991). The two high counts were not associated with declines in production and although they are higher than expected, they cannot be interpreted as indicating a disease problem. It should also be noted that there are a number of low or non-pathogenic species of *Eimeria* recorded in chickens, and as all oocysts less than 20µm in length were recorded as *E acervulina*, the possibility that the two elevated counts could be due to these apathogenic species cannot be excluded. Small numbers of cestode eggs were recorded from 3 farms in the first round, but none from the second. These were not identified further.

4.19. CONTROL MEASURES USED AGAINST HELMINTH INFECTIONS

The FEC counts of ascarids and *Capillaria spp* in relation to the treatment practices recorded in the survey are shown in Table 30. Flubenol (5 percent flubendazole Janssen) is the only anthelmintic registered in New Zealand for use in poultry that does not have an egg withholding period. It is recommended for use as a treatment/ prophylactic via the feed (30ppm flubendazole) every 3 to 4 months, but may also be used as a continuous additive at 4ppm flubendazole for the early part of lay. 14 farms stated that they used Flubenol, but the frequency and dose rate was not stated. A number of organic farms used garlic and/or cider vinegar. The ascarid FEC were significantly higher in the cider vinegar/garlic treated flocks at the first visit, compared with flocks using no treatment at all: (p<0.05 using Mann-Whitney test).

Table 30: Prevalence and FEC of nematode eggs according to treatment practices. Epg counts relate to the mean and range FEC of the positive farms.

Treatment	No farms using	Mean Age V1	Ascarid	Capillaria	Mean Age V2	Ascarid	Capillaria
		wks	epg +ve (range)	epg +ve (range)	wks	epg +ve (range)	epg +ve (range)
Flubenol	14	33	513 (50-1300)	186 (50-700)	63	755 (3000-50)	219 (50-250)
<i>farms positive</i>			8	7		11	8
Not specified/levamisole	3	28	400	700	63	150	350 (200-500)
<i>farms positive</i>			1	1		1	2
Cider Vinegar/Garlic	6	32	1220 (800-2350)	430 (50-1000)	61	1220 (50-1350)	94 (50-200)
<i>farms positive</i>			5	5		5	4
No Treatment used	12	31	533 (200-1250)	280 (100-600)	63	650 (50-2600)	167 (50-350)
<i>farms positive</i>			9	5		11	3

Where Flubenol is used in a treatment/preventive programme, this is generally carried out in early lay, hence the visit 1 figures are likely to be show any benefits from this treatment. The

results from visit 2 will be more affected by external factors including *weather* (flocks were examined from February [dry] to June [wet but soil temperature still high], which affects the maturation of the worm eggs on range, and *development of age-resistance* – older flocks are likely to have a higher prevalence of infestation but their development is retarded resulting in worms in older flocks producing lower numbers of eggs (Arends, 2003).

4.20. ECTOPARASITES

Table 31: Prevalence of ectoparasites

Management System	No birds	Avg Age (Wks)	Birds Mite Free	Birds with mites		No birds	Avg Age (Wks)	Birds Mite Free	Birds with mites	
				No.	No. farms				No.	No. farms
Visit 1						Visit 2				
birds examined	1805	32	1764	41	5	1773	62	1704	69	5
Large Cage	362	31	331	1	1	361	63	361	0	0
Small Cage	390	33	382	8	1	390	64	390	0	0
LFR	300	31	270	30	2	270	59	240	30	1
SFR	300	29	235	2	1	300	62	276	24	3
OFR	303	36	303	0	0	302	67	302	0	0
Barn	150	32	150	0	0	150	59	135	15	1

Red mites (*Dermanyssus gallinae*) were the most common ectoparasite in the birds examined – see table 31. Small numbers of birds had lice (species not identified), and one farm the mites found were the Northern fowl mite (*Ornithonyssus sylviarum*). In no cases were the flocks heavily infested (in only one flock were all the birds examined infested, and in all other flocks infestation was detected in a small number of birds). As the birds were examined during the day it is possible that the true prevalence of mite infestation is higher, as *D gallinae* spends most of its time off the bird (Arends 2003).

4.21. IMPACTION OF THE GASTRO-INTESTINAL TRACT

This has been described as a cause of impaired production and increased mortality in free range birds in New Zealand (Christensen, 1998). In the current survey one large free range farm and 4 organic free range farms indicated that they had experienced problems with impaction in recent flocks.

5. Behaviour Assessment

Table 32: Summary of behaviour assessment in cage birds

Behaviour type	Avg birds assessed	Avg Aisle width cm	Birds showing behaviour type at time				Aggressive Events avg per scoring session	
			T ₀	T ₁	T ₂	Average of T ₀ ,T ₁ ,T ₂		
Visit 1								
positive	110	109	<i>Large cage</i>	42.9%	52.4%	60.2%	51.8%	2.2
	104	133	<i>Small Cage</i>	58.8%	68.6%	73.5%	67.0%	1.9
neutral			<i>Large cage</i>	29.9%	24.1%	18.3%	24.1%	
			<i>Small Cage</i>	14.3%	11.6%	11.8%	12.6%	
aversion			<i>Large cage</i>	27.2%	23.6%	21.5%	24.1%	
			<i>Small Cage</i>	26.9%	19.8%	14.7%	20.6%	
Visit 2								
positive			<i>Large cage</i>	27.8%	37.1%	45.7%	36.9%	0.9
			<i>Small Cage</i>	49.9%	55.3%	60.6%	55.2%	2
neutral			<i>Large cage</i>	34.8%	30.7%	24.0%	29.8%	
			<i>Small Cage</i>	27.4%	24.8%	21.4%	24.5%	
aversion			<i>Large cage</i>	37.3%	32.3%	30.3%	33.3%	
			<i>Small Cage</i>	22.7%	19.9%	18.1%	20.2%	

The results of the assessment of behaviour in cages show that the percentage of birds showing positive behaviour (putting their heads out of the cages or resuming feeding) increased over the 4 minutes observation time. This was accompanied by a decrease in the numbers of birds showing neutral or aversion behaviours. The birds on small cage farms showed a higher percentage of positive behaviour than birds on the large cage farms, although the increase in positive behaviours over the 4 minutes observation time was similar between the two groups (table 32). It was initially thought that the higher percentage of positive behaviours assessed in the birds on smaller farms was due to between-assessor variation, as one assessor scored more positive behaviours across both cage groups, and this assessor had a disproportionate number of small farms (data not shown), but the multinomial model developed for statistical analysis of behavioural analysis showed no statistical differences between assessors.

Irrespective of statistical analysis, the relationship between T₀, T₁ and T₂ assessments was not affected; this showed there was a consistent increase in positive behaviours from T₀ to T₁ to T₂ which was consistent across all assessors.

Observers noted that the level of positive behaviours in the cages on the smaller farms appeared to be highest amongst birds in the old-fashioned single tier or A-frame cages, but the number of these farms was too small for more detailed analysis.

Table 33: Summary of behaviour assessment in non-cage birds

	No farms	Av No. birds assessed	% birds showing behaviour			Aggressive Events avg per scoring session
			Positive	Neutral	Aversion	
Round 1						
LFR	9	128	36%	53%	11%	1.8
SFR	10	65	37%	52%	11%	0.3
OFR	10	61	18%	74%	7%	2.9
Barn	5	83	37%	49%	14%	3.0
Round 2						
LFR	10	63	36%	50%	12%	4.9
SFR	10	69	33%	57%	10%	0.9
OFR	10	72	38%	54%	7%	1.5
Barn	5	79	34%	46%	19%	1.6

The results from the non-cage systems (table 33) were remarkably consistent and show neutral behaviours predominating in all systems at both scoring sessions. In other words, most birds simply carried on what they were doing and ignored the observer. Most of the aversion events involved birds walking away from the observer, which is only mild form of aversion.

The scoring of behaviour in both cage and non cage systems advocated by the LayWel (2006) project centres on weekly observation rather than a one-off exercise that was necessary for the current work. In the case of cage systems the LayWel document advocates walking slowly past the cages and noting the proportion of birds that continue feeding, stop feeding (and looked up), withdrew heads, or move to the back of the cage. This proved quite impractical to monitor as most birds withdrew into the cage as the observer approached, which proved difficult to record with any reliability. A modification of this system would be to record the numbers of cages behind the moving observer at which the birds were resuming feeding activity after the observer had passed.

One aspect of the cage behaviour assessment that the LayWel authors appeared to have missed or ignored, is that in most, if not all, modern conventional cage systems, the drinker nipples are located at the back of the cages and therefore birds have to display an “aversion” behaviour in order to drink

5.1. COMPARISON OF BIRD BEHAVIOUR IN RESPONSE TO ASSESSORS BETWEEN ALL FLOCK TYPES

Figure 6 shows the proportion of each behaviour type displayed by birds at each inspection visit for each flock housing type. From the data it appears that birds from cage housing systems display less neutral behaviour than free range flocks.

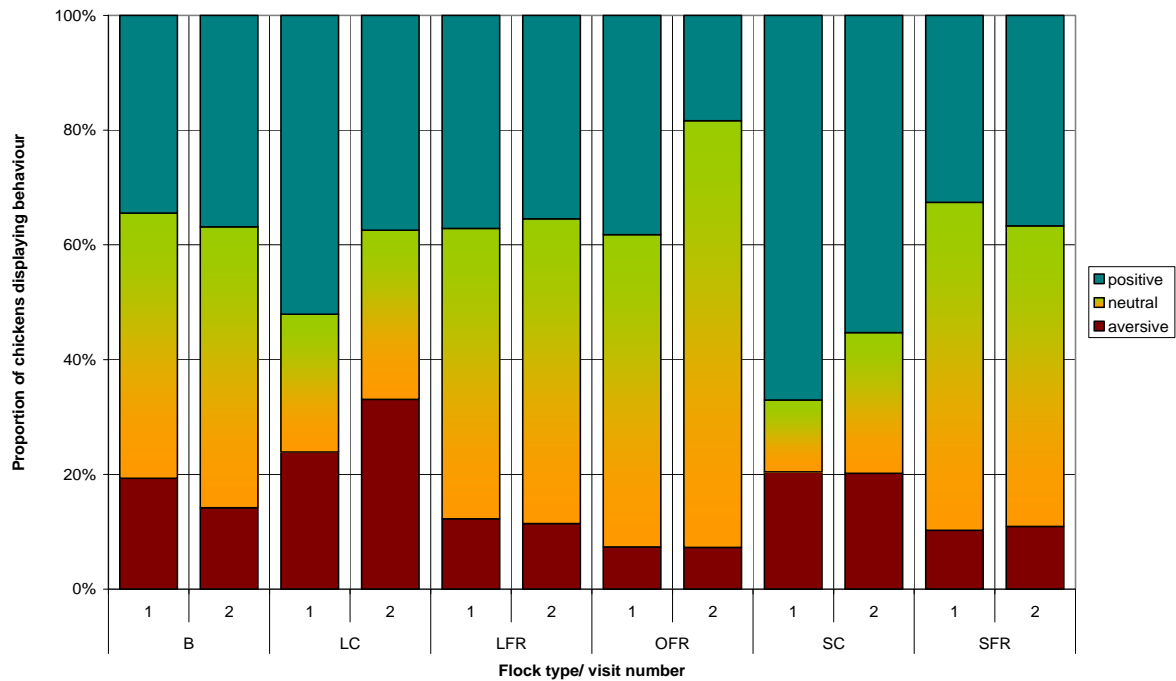


Figure 6: Proportion of three behaviour types (positive, neutral and aversion) by flock type and visit number

A multinomial model was developed for the analysis of the behaviour assessment data. The response variable had three possible outcomes; 1=positive, 2= neutral and 3= aversion. The large cage (LC) flock type was used as the reference level for type and the model compared the ratio of neutral behaviour to aversion and positive behaviour to aversion separately.

The only significant finding in the model was the cage flocks appear to display less neutral behaviour compared to aversion behaviour. The exponentiated coefficients of the model represent an odds ratio.

The ratio of neutral to aversion behaviours for LC flocks was 0.11 (0.01427 -0.79018) $p=0.03$ and for SC flocks 0.10329 (0.01245 - 0.85728), $p= 0.04$. The following variables were not significant in the model; assessor (no significant difference detected between the assessors of the flocks), beak trimming (a variable indicating whether flocks were beak trimmed using cautery, laser or not at all) and visit number (no significant difference in behaviour was detected from visit 1 to visit 2).

5.2. FAECAL CORTICOSTERONE MEASUREMENT

The results of the analyses of faecal corticosterone in the group of five farms with both cage and free range operations are shown in tables 34 and 35. Five farms with both caged and free-range birds were visited on two occasions. Three composite faecal samples per production system were collected from each farm on each visit. These were analysed for faecal corticosterone concentrations in ng/g. Table 34 shows the mean, median and range of values obtained for each production system for each visit. Figure 7 illustrates box plots of the faecal corticosterone concentrations by production system and visit number.

Table 34: Faecal corticosterone concentration in 5 groups of free range and cage-housed birds in early lay (visit 1) and late lay (visit 2)

	Free Range visit 1	Cage visit 1	Free Range visit 2	Cage visit 2
Faecal corticosterone concentration (ng/g)				
Number of values	16	14	15	15
Minimum	6.85	7.91	7.53	7.57
25% Percentile	9.60	8.62	10.08	8.88
Median	11.84	11.45	12.10	11.04
75% Percentile	15.87	13.30	13.27	14.21
Maximum	26.85	16.38	17.42	19.00
Mean	13.09	11.54	11.92	11.93
Std. Deviation	5.10	2.75	2.78	3.28
Std. Error	1.28	0.74	0.72	0.85

A series of three Analysis of Variance analyses was conducted comparing Cage vs Free range values for Visit 1, Visit 2, and Visits 1 and 2 combined. The first ANOVA compared Cage vs Free range measured at visit 1, the second compared levels measured during visit 2, whilst the third compared Cage vs Free range values using all samples (both visits combined). These ANOVA produced p-values of 0.21, 0.73 and 0.22 respectively, indicating no significant differences between Cage and Free range systems. This data is presented as a box and whisker plot in figure 7. The overlapping boxplot notches confirming that there were no significant differences in faecal corticosterone levels between the two production systems

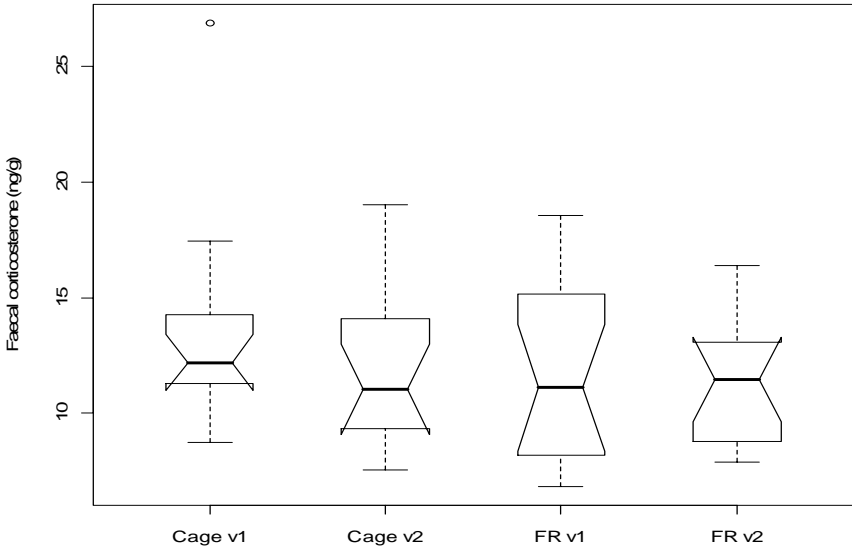


Figure 7 Boxplots of faecal corticosterone concentrations by production system and visit number. Solid lines indicate medians, hinges (tops and bottoms of boxes) indicate quartiles, and notches indicate 95 percent confidence intervals for the medians.

The faecal corticosterone data for individual farms is shown in table 35. In the present study there was little variation in the faecal corticosterone levels between free range and cage-housed birds on the same property at the second visit when the birds averaged 62 weeks of age. At the time of the first visit, there was greater variation on two farms; on farm 4 the free

range birds showed higher levels of faecal corticosterone, whilst the reverse was the case on farm 5.

Table 35: Faecal corticosterone concentration in 5 groups of related free range and cage-housed birds in early lay (visit 1) and late lay (visit 2), shown as individual farm mean values

Farm No	Visit 1 Faecal corticosterone concentration (ng/g)		Visit 2 Faecal corticosterone concentration (ng/g)	
	Mean (std dev)		Mean (std dev)	
	FR	Cage	FR	Cage
1	13.35 (2.45)	13.88 (1.27)	14.23 (2.02)	14.85 (4.33)
2	7.88 (1.22)	11.79 (1.48)	9.81 (2.69)	10.76 (4.14)
3	14.41 (3.18)	14.96 (2.63)	10.08 (1.79)	12.89 (1.65)
4	14.69 (4.45)	9.98 (1.18)	10.88 (1.79)	8.73 (1.11)
5	8.99 (1.91)	16.84 (8.68)	12.12 (1.59)	12.44 (1.90)

Spearman's rank correlation (*rho*) was used to investigate the relationship between faecal cortisone levels and flock mean integument score using the combined data from both visits to the 5 sample farms and both free range and cage flocks. There was no correlation (*rho*=0.123, p-value =0.604).

No significant association could be demonstrated between faecal corticosterone levels and behavioural data.

Fraisse and Cockrem (2006) reported faecal corticosterone concentrations of 12.45 (std dev 1.29) ng/g; for brown layers and 12.31 (std dev 0.66) ng/g for white layers. These values are very close to the concentrations of 13.09 and 11.92 ng/g (free range) and 11.54 and 11.93ng/g (cage) reported in the present study. If the outlying value of 26.85 ng/g found in a single free range sample from farm 5 is excluded, this mean becomes 12.17ng/g.

In common with other studies (Koelkebeck and Cain 1984) and (Mench *et al* 1986), (Craig *et al* 1986) this study showed little correlation between corticosterone values and behavioural assessments or production data, although plasma corticosterone was measured in these studies, which were carried out under experimental conditions.

6. Discussion

There were no major adverse welfare issues highlighted by this survey, and there was generally a high level of compliance with the Code of Welfare and its Minimum Standards.

Current husbandry requirements have changed so that Minimum Standards were not generally adhered to in the area of weighing birds during rearing or during lay (see tables 7 and 8). The Code may reflect the situation some years ago prior to the introduction of modern light hybrids, when feed and weight restriction in rear and lay were essential to maintain welfare and production. The Minimum Standard specifies the number of birds that should be weighed but is silent on the more important issue of whether they should be bulk-weighed or individually weighed. As egg layers are fed ad-lib, weighing of birds does not help in calculating feed allowances, but can be used to regulate intake through varying house temperature or nutrient composition of a feed. To apply such measures successfully, requires sophisticated environment control capability, and that an individual flock's feed supply can be controlled. In multi-age houses containing up to six age groups, this control cannot be achieved, so there is little production advantage in weighing the birds frequently. At a comparative level the use of single-age flocks that might benefit from individualised feed control was more prevalent in barn and free range operations than in cage systems, but the level of environment control required is generally absent. Weighing was used as a production management aid in approximately half of large cage farms, but in fewer than 20 percent of other management types. This survey showed that flocks' average weights were maintained close to breeders' guides, but there is a considerable variation in weight amongst flock members. Although the weight variation from breeders' standards is marked, the high percentage of birds in lay suggests that any effects on bird welfare arising from non-observance of Minimum Standard 2f of the Code are small.

A feature of the cage production systems in this study was their lack of variability between and within flocks in respect of many of the parameters included in the survey. This is reflected in the low variability in performance measures, including mortality, amongst cage flocks. Cage production systems on both large and small farms showed the lowest levels of mortality, significantly ($p < 0.001$ [OFR], 0.001 [LFR] 0.03 [SFR]) lower than on free range systems. Barn production systems showed mortality rates intermediate between cage and free range systems, but not significantly different to either. Mortality rates are a crude measure of welfare, but an important one, worthy of considerable weighting in any comparison of the relative merits of any production system, as hens generally suffer during the period of morbidity preceding death, whether from cannibalism (Newberry 2003) or disease.

In the present study, assessment of birds integument using the Tauson scoring system showed a significant increase ($P < 0.001$) in the level of wounds in organic free range flocks at the time of the second visit, as compared to birds housed in other free range, barn and cage housing systems. Large free range flocks had significantly more wounds than the reference LC flocks ($P = 0.011$). Six of the 10 organic free range flocks were not beak trimmed, and the other 4 had been trimmed using a Novatec laser beak trimmer. 8 percent of the other extensive flocks and 16 percent of the cage flocks were not beak trimmed. In the case of the cage-housed flocks this included the largest flocks, where the standards of light and environmental control allow birds to be farmed without trimming their beaks. Some allowance should be made for the fact that the organic free range flocks were on average 5 weeks older than for the sample as a whole, but the elevated levels of aggression shown by these birds, coupled with the presence of an effective means of conveying aggression in the form of a sharp non-trimmed beak underlies the high level of wounds in OFR flocks. The fact that the wounds do not transfer to

a higher level of mortality probably reflects the increased opportunities for escape provided by these systems.

Cage systems also showed a significant reduction in feather covering as compared to non-cage systems by the time that the birds reached 60 weeks of age, most marked in the birds on small cage farms. In this study feather loss was greatest in those birds (cage birds) producing the most eggs, reflecting abrasion of feathers on cages and other equipment. This matches the findings of Hughes (1983) who scored feather loss on the neck and crop of 61-week old birds, where there was also a close relationship between egg output and feather loss, which he attributed to abrasion of feathers on equipment during pre-laying behaviour. Studying free range systems Nicol et al (2003) utilising a cluster analysis technique showed that feather pecking was not associated with any particular (non-cage) husbandry system, and that the only significant risk factor was use of the outdoor range, in which feather pecking was reduced in flocks where more than 20 percent of birds used the range. Use of range was positively associated with the presence of trees and/or hedges on the range. Although images of featherless birds in cages have often been used in campaigns against the use of laying cages, the direct implications of poor feather cover on bird welfare have not been frequently canvassed. Blokhuis and Wiepkema (1998) highlight a conflict in the feather-covering debate by asserting that the introduction of alternatives to battery cages is hampered by feather pecking and cannibalism. Our results and those of others show that feather loss is more marked in cage birds than in birds housed in non-cage systems, but the presence of wounds is more prevalent in the latter.

Animal welfare studies have attempted to assess feelings experienced by animals: the absence of strong negative feelings, usually called suffering, and (probably) the presence of positive feelings, usually called pleasure. In any assessment of animal welfare, these feelings should be assessed, but because feelings are subjective they cannot be investigated directly. Indirect methods are available. These are usually derived from assessing the changes in an animal's structure (e.g. feather cover, wounds) and functions (egg production) and also from their behaviour (Duncan 2005). Feelings that are particularly difficult to measure in layer hens include response to confinement, and the effects of lack of perching, flapping/flying and dust bathing opportunities associated with the cage environment.

Measurement of impaired biological functioning, particularly impairment connected to decreased health and increased physiological stress responses, can provide good corroborating evidence that welfare is compromised. This is the basis of Duncan's (2005) biological functioning approach to animal welfare assessment. Conversely, it is reasonable to deduce that animals producing well, showing low prevalence of morbidity and/or mortality, and normal behaviours are suffering little physiological stress.

Although science can be of enormous help in resolving animal welfare problems, readers should remember that the driving force behind this science is society's ethical concern about the quality of life experienced by farm animals (Duncan 2005). Social attitudes vary widely even among developed OECD societies. In the European Union conventional battery cages are currently scheduled to be banned from 1 January 2012, while the situation in North America may remain unchanged for a long time, i.e. most farmers will stick with conventional cages (Sorensen and others 2006), although Californian voters accepted a proposal to ban cages (Proposition 2) in their state in a referendum at the time of the 2008 presidential election. Current economic circumstances have resulted in a shift in consumer actions (as opposed to intentions) towards seeking more value-based food solutions. One of the outcomes of this survey is that any consumer seeking value-based protein can be assured

that he or she need not avoid eggs produced in any farming system in New Zealand on the ground that birds are suffering unnecessarily in that system.

A key question is whether more extensive poultry production systems (free range and barn) offer quantifiable superior welfare outcomes for birds than do cage systems?

What does the term ‘welfare friendly’ mean? It infers that animals kept in such systems are more comfortable, suffer less, have more freedom and are more content. But is it based on facts or perception? This study has focussed on defining welfare outcomes for layer hens based on known needs.

The Pew Commission Report of 29 April 2008 claims that practices which restrict natural motion, such as confinement, induce high levels of stress. Faecal corticosterone, behavioural and biological findings of this study do not support this contention. The Pew report also claims that good welfare can no longer be assumed based on high productivity and/or absence of disease. It bears repeating that good hen welfare is almost always accompanied by low mortality and high levels of productivity. The internet offers the public science-based welfare information on websites such as FarmIssues.com comparing intensive, low cost egg production systems with those based on systems in which hens have better perceived welfare conditions (Hunton 2008). The Pew Commission seek consensus based standards for animal welfare, whilst this study has examined layer hen welfare through science-based measurement of the birds physical condition, and physiological behavioural responses in the different environments included in the study.

Free range hens have been assessed in overseas studies as being at greater risk from disease morbidity and mortality, and as being exposed to more aggressive behaviour from their peers. This study provides data to confirm this under New Zealand conditions.

For several variables used to assess hen welfare in this study, more variation was found within, as compared to between, the farm types (the exception being the large cage farms which showed very little variation as a group). Examples of good and poor hen management practices impacting on bird welfare were apparent in each of the farm systems examined. Consideration has been given to these results using the scientifically-determined biological-functional and behavioural indicators of the feelings of the hens, and in the context of societal expectations

The findings of this study indicate that cage, barn and free range farmed layer hens in New Zealand were similarly adapted to, and coping with their respective environments. This is illustrated by the absence of statistical differences in measures of behaviour and faecal corticosterone test results between groups. Laying hens in conventional cages have been assessed as being at risk of suffering poor welfare outcomes for key indicators compared to birds in other categories of housing system (LayWel 2006), mainly because they express a limited behavioural repertoire. These perceptions of conventional cages will probably not be dispelled by the results of this survey. Nevertheless, a high level of adaptation is, at the very least, a necessary condition for good bird welfare, and the behavioural results of this study show that birds in cages appear as well adapted to their environment as free range and barn hens are to theirs.

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9. Appendices

- Appendix 1** **A standardised questionnaire to collect detailed information covering overall farm management practices.**
- Appendix 2** **A questionnaire covering the history and management of the flock being assessed. Production and mortality data were also recorded as part of this process**
3a Cage farms; 3b free range and organic farms; 3c Barn farms
- Appendix 3** **A physical condition scoring tool based on published methods. (Tauson and others 2005).**

Appendix 1

Standardised questionnaire to collect detailed information covering overall farm management practices

Page 1

Farm Name				RMP No	
Address				Agribase No	
Person in Charge of Hens					
EPF Self Audit Checksheet completed					
Physical description of Farm					
Production type (<i>circle</i>)	Cage	Barn	Free Range	Organic FR	<i>(if more than one production type circle as needed)</i>
No. of birds in each system					
Layer strain	SX Brown	Hyline Brown	Hyline White	Shaver White	Other
No. of birds of each type					
Ages of birds at visit	18 -30 wks	31-45 wks	46-60 wks	60-80 wks	>80 wks
No of birds in each age range					

Page 2

Depletion of birds at end of lay		Average age at depletion (wks)				
Method of slaughter and/or disposal of birds at end of lay (<i>circle method(s) used</i>)	Commercial slaughter	Manual neck dislocation on farm	Gassing	Chookbuste	Sold Live	
Moulting						
Flock Management (all types)						
Feed (Layer Feed)	Home Mill	Commercial	Mash	Pellets	Crumble	
Rearing	Self	Pullet rearer	Age at move from rearer (wks)		Floor	Cage
Beak trimming	Laser	Lyon (caute)	Not trimmed			
Do you routinely weigh birds	Y/N	if yes	how often	Rearing	Laying	
			how many birds			
			individual birds			
			Bulk			
			Do you weigh all birds in cage			
			Do you weigh the same cages			
Storm Water Drainage		Alarms and Back up Power	OK			

Appendix 2

Questionnaire covering the history and management of the flock being assessed. Production and mortality data were also recorded as part of this process

3a Cage farms

Standard set temperature (auto	°C	Not available	Measured temperature		No birds in shed		No. birds of as	
Equipment manufacturer	Salmat	Big D	Cagemaster	Farmer Automatic	Other		Old fash	
Dimensions of each cage (cm)	Length		Width		Min Height		Cag e	Solid Wire
No of birds housed per cage (POL)								
Hot wire installed	Y/N	Is it used	Y/N					
Have you ever had problems with hot wire		If yes describe						
How many tiers high are cages								
How many water points can each bird reach			Cups	Nipples	Troughs		Assessor check	
Ventilation	Natural	Cross Flow	Tunnel					
Do you have problems with ammonia build up		Y/N	Assessor ammonia detection					
Lighting programme (in lay)			Light colour (natural, incandescent, fluorescent white, blue, green)					
Feeding	Ad Lib	Times per d	Do you use a midnight feed)					

3b Free range and Organic farms

Page 1

Type of shed assessed	Movable			Shed size length x width		No birds/shed
	Fixed (earth floor)			Birds/flock		
	Fixed (concrete floor)			No. of arks		
	Slats	Y/N	if so % floor covered by slats			
	Manure removal		At depletion	Conveyor/scrapper (frequency)		
No of paddocks per flock available for rotation		Vegetation coverage	Well grassed weedy bare	Have you had problems	Y/N	
Management between flocks	Fallow	Re-sown	none	other (describe briefly)		
Drainage assessment	Good	fair	poor			
by farmer						
by assessor						
Wintergarden/Verandah available	Y/N	covered by (circle) metal/ earth/wire/other				
Outside shelter eg trees/hedge/ shadecloth						
Do you have trouble with hawks, stoats		Y/N	if yes, brief details			

Page 2

Egg collection	Manual		Automatic		Manufacturer	
No Birds per nest		Nest Space per bird (automatic)		E.g Vencomatic		
Nest box substrate e.g. carpet, shavings, old cages						
Floor Litter material (shed floor)		% litter friable		Litter condition under drinkers		
Electric wires to control floor	Y/N					
Drinkers	Bell	Nipples	Cups	Troughs	Is water supplied out	
Birds/drinker	No.	No.	No.	length	Puddles?	Y/N
Worm Control practised	Y/N		Mite Control practised		Y/N	
Lighting programme (in laying shed)			Light colour (natural, incandescent, fluorescent white, blue, green)			
Feeding	Ad Lib	Times per day			Do you use a midnight feed	
Ventilation (in shed)	Natural	Cross Flow	Tunnel			
Do you have problems with ammonia build	Y/N			Assessor ammonia detection		

3c Barn farms

Page 1

Shed size Length x width	Concrete Floor	Earth Floor			
Set Temp	Measured temp				
Are Slats used	Y/N	if so % floor covered by slats	Slat material (Plastic/ wood)		
No of birds/shed	Manure removal	At depletion	Conveyor/scrapper (frequency)		
			Manure coming through slats		
Type of egg collection equipment	Manual	Manufacturer			
	Automatic	e.g Vencomatic			
Birds/nest or	Nest Space per bird (automatic)				
Litter material		% litter friable	Litter condition under drinkers		
Electric wires to control floor	Y/N				
Drinkers	Bell	Nipples	Cups	Troughs	
Birds/drinker	No.	No.	No.	Length	
Worm Control practised	Y/N		Mite Control practised	Y/N	
Lighting programme (in lay)			Light colour (natural, incandescent, fluorescent white, blue, green)		
Feeding	Ad Lib	Times per day		Do you use a midnight feed	
Ventilation	Natural	Cross Flow	Tunnel		
Do you have problems with ammonia build	Y/N			Assessor ammonia detection	

Appendix 3 Physical examination

Farm Name

Individual bird examination 30 birds per farm unit

Flock ID	Breed	Age (wks)	Breeders Std weight (kg)
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Welfare Score (Tauson: www.livsmedelssverige.org/hona/scoring system)

Bird	Weight (Kg)	Feet (1-4)				Keel 1-4	In Lay Y/N	Integument (1-4)							Wounds (1-4)				Mites R, W	
		Pads	Toes	Claws	AVG			Tail	Vent	Wings	Breast	Neck	Back	AVG	Vent	Body	Comb	AVG		
1																				
2																				
3																				
4																				
5																				
6																				
7																				
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28																				
29																				
30																				

Total/avg