Client Report

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Key indicators of poultry welfare in New Zealand

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EXECUTIVE SUMMARY

- There is currently a high level of interest by policy/regulatory authorities, the public, welfare organisations, growers and lobby groups in the welfare of poultry kept for meat production.

- Thus, there is an urgent need to identify key welfare indicators relevant to New Zealand conditions, use these measures to assess the welfare status of broilers under common farming practices, and, where necessary, revise practices in industry, and standards and recommendations in the relevant welfare codes.

- At the beginning of the study, a Broiler Welfare Research Committee (BWRC) was formed (with representation from Poultry Industry Association of New Zealand (PIANZ), poultry veterinarians and representatives from the major meat chicken companies in New Zealand, a scientist from AgResearch and an independent scientist to oversee the research programme.

- The aim of the research was to identify appropriate welfare indicators for broilers, and apply them to quantify the welfare status of broilers in New Zealand.

- This study used a suite of measures to assess welfare including: the incidence (and causes) of mortalities and culls; skin disorders of the feet, hocks and breasts; gait score; and the incidence of back scratches, birds dead on arrival (DOA), rejects.

- The potential influence of management factors on welfare was examined through information collected in a grower survey.

- The potential influence of stocking density was examined by correlating welfare measures with variations in stocking density that arose naturally during the study.

- The research was carried out on 36 New Zealand housed commercial broiler farms in each of the four seasons and within the context of the typical management of the birds. There were few differences in husbandry practices between farms.

- Overall mortality was 3.8%, which is at the lower end of levels typically seen in the industry overseas. Of all the birds in the study, 0.3% died as leg culls.

- The contribution of leg culls to total mortality was relatively low (8%) and about half that reported for birds in two recent UK studies (15%).

- The proportion of birds with severe leg weakness (gait score 4 (0.78%) and 5 (0.1%)) was about one quarter that reported for broilers in the UK, Denmark and Sweden.

- Considering both the leg culling and gait scoring information together, our results demonstrate that leg health in New Zealand broilers is better than for birds in Europe.

- Prevalence of all forms of contact dermatitis (footpad, hock burn and breast blisters) was within the range reported internationally. Incidences, such as occurred, were mostly of a relatively minor nature. These data indicate that the litter in the houses is maintained in good condition, although there were seasonal variations.

- Pre-slaughter handling procedures, as assessed by Dead On Arrivals and reject birds, were generally better than reported for other countries. The proportion of birds with back scratches averaged 39%. Meaningful comparisons between our data and the incidence of scratches reported elsewhere were not possible due to the lack details of the measurement criteria provided in other published reports

- Stocking density varied between 32.9 and 39.3 kg m^{-2}. Stocking density was not correlated with any of the welfare measures, or variables in the epidemiological survey, suggesting that broiler welfare is either unaffected by stocking density, or that the range in densities seen in the current study was too small to enable correlations to be detectable. Stocking density (at the levels currently used in this study) would appear appropriate as the welfare of the birds is good.

- The welfare of broilers in New Zealand is equal to or superior to that of broilers kept elsewhere.

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INTRODUCTION

There is currently a high level of interest by policy/regulatory authorities, the public, welfare organisations, growers and lobby groups in the welfare of poultry kept for meat production. Much of this interest has been brought into focus by the New Zealand Animal Welfare Act (1999) and associated Code development. In order for all interested parties to be confident that the standards of welfare specified in Codes and practised on farms are at acceptable levels, scientifically-defensible information on the welfare of broilers in New Zealand is required. Published scientific information has been reviewed for MAF (Bagshaw and Matthews, 2001). There is a considerable international literature on broiler welfare but, unfortunately, there are no relevant published details on the welfare status of poultry in New Zealand. Bagshaw and Matthews (2001) indicated that while there are many similarities in the way that poultry are farmed in NZ and elsewhere, there are likely to be important differences (e.g. in disease status) which may influence overall welfare. Thus, there is an urgent need to identify key welfare indicators relevant to New Zealand conditions, use these measures to assess the welfare status of broilers under common farming practices, and, where necessary, revise practices in industry, and standards and recommendations in the relevant welfare codes.

In the United Kingdom a survey of the welfare status of broilers has been undertaken at Bristol University. The data generated by Bristol would benchmark broiler welfare in the UK. It was proposed that a New Zealand study on the welfare of broilers be of a similar format to that in the Bristol study. It is important that the work carried out in NZ is internationally credible. In addition, comparing welfare standards between countries (e.g. UK and NZ) would be useful and will be carried out when both reports are available.

The main causes of poor welfare in other countries are leg disorders, diseases, skin disorders (primarily associated with poor environmental conditions) and damage during catching and transport to slaughter. The low levels of activity and a limited

behavioural repertoire are also considered by some authors to indicate poor welfare (Berg et al., 2000).

Leg weakness can arise from infectious and non-infectious causes and its prevalence can be influenced by a wide range of management factors (e.g. genotype, live weight, feeding level, lighting regime, activity levels) (Butterworth, 2004).

Typically, leg weakness has been assessed using the gait scoring procedure developed by Kestin et al.(1992) which uses a 6 point gait score (GS) scale (0 being normal, through to 5 being immobile). Using this system with the Ross genotype and birds aged 42 to 49 days and weighing 2.6 to 2.8 kg, Kestin and colleagues reported that the percentage of birds with gait scores 0 to 5 were 8.5, 22, 43, 21, 4 and 2.5, respectively. Sanotra et al. (2003) reported percentages of 26, 25, 25, 19, 4 and <1% in these GS categories for Ross and Cobb genotypes slaughtered at 35 days of age and with a mean weight of 1.8 kg . It should be noted that the percentage with gait score 0 (26%) is extremely high compared with other published reports.

Leg weakness might adversely affect welfare either directly (e.g. through pain) or indirectly (e.g. through preventing the fulfilment of essential functions like feeding).

There is some evidence, though not unequivocal, to suggest that higher gait scores (3 and over) result in broilers experiencing pain. The evidence has been derived from two types of studies: in one, the effects of analgesics on behaviour have been measured; and in the second, the effects of gait on the propensity to exhibit specific important activities have been assessed. Using an analgesic/anti-inflammatory drug, carprofen, (McGeown et al., 1999) compared the time taken by broilers with gait scores of 0 or 3 to traverse an obstacle course, with and without prior drug administration. Gait score 3 birds birds with and without carprofen negotiated the course in 18 and 38 seconds, respectively, while birds with sound legs took 11 seconds. The times taken for the sound birds and carprofen treated gait score 3 birds were not significantly different. Danbury et al. (2000) reported two

experiments in which gait score 0 and 3 birds were offered a choice of carprofen and untreated food. In one study, there was no difference in the consumption of drug-treated and untreated food between gait score treatments and, in the second, the amount of drug-treated food eaten increased with gait score. These data were interpreted as indicating an increasing level of drug self-selection (and therefore pain relief) with increasing gait score. However, this study requires replication before firm conclusions can be drawn due to: the inconsistencies between the two experiments; the lack of a significant difference in drug concentration in the plasma between birds with sound and unsound legs; the correlation between consumption of drug-treated food and gait score apparently being driven entirely by a lower consumption rate by the gait score 0 birds; and the measures of gait score used in the analyses being taken at the end of the study, meaning that drug consumption and gait score were totally confounded. Further, there were no differences in the plasma concentrations of carprofen between birds with different gait scores.

Indirect measures of the welfare impacts of variations in gait score include the research by Bokkers and Koene (2004) and Weeks and Kestin (1997) where the behaviour of birds with different gait scores has been compared. While some aspects of broiler behaviour are modified in a way that suggests that lameness (GS 2 and 3) imposes a cost on the birds (e.g. increased feeding bout duration, reduced motivation to feed), there is no effect of lameness on total time spent feeding or drinking (Ross genotype; Weeks et al., 2000). Nonetheless, as Mench (2004) has aptly stated, many gait disorders must be painful as a consequence of the clinical manifestations involving inflammation, spinal cord damage, tension on the joints or rupture of tendons.

Broilers live on a litter substrate. If the litter is too damp, then the birds may develop contact dermatitis on the foot (footpad dermatitis), hock (hock burn) or breast (breast blister). Dryness of litter is influenced by a wide range of factors including the effectives of the ventilation system, climate, food composition, litter

type, stocking density, drinker system and bird health (Berg, 2004). The mean percentage of birds seen with the various forms of contact dermatitis is 7 to 19% (range up to 90%) for hock burn (Dawkins et al., 2004; Menzies et al., 1998), 19% for foot pad dermatitis (Dawkins et al., 2004), and 0.0 to 0.4% for breast blisters (Berg, 2004; Hall, 2001).

Average total mortality in flocks is reported to vary from a low of about 2.5% (Butterworth, 2004), but is more likely to be in the range from 4 to 6.5% (Hall, 2001, Dawkins et al., 2004). About 15% of the total mortality arises due to culling for leg weakness, 35% due to culling for other reasons, and 50% from natural deaths (Hall, 2001, Dawkins et al., 2004). As a proportion of the flock, leg culling rates have been observed in the range 0 to 4% (McNamee and Smyth 2000; Dawkins et al., 2004).

The most common causes of leg weakness in broilers are reported to be femoral head necrosis (17 to 38%), limb deformities (11 to 14%), tibial dyschondroplasia (7 to 8%), Infections (13%), and spondylolisthesis (kinky back) (3 to 8%) (Butterworth, 1999; McNamee and Smyth, 2000).

Pre-slaughter handling is comprised mainly of the catching, containment and transport of birds to slaughter. Measures to assess the impact of these procedures on bird welfare include mortalities post-transport (dead on arrival, DOA) (Mitchell and Kettlewell, 2004), rejects or downgrades of the carcasses due to, for example, trauma or bruising (Scott, 1993), and other measures of injury (e.g. back scratches (Hall, 2001). Of course, some traumatic events and other variables (e.g. disease conditions, (Ekstrand, 1998) occurring prior to the pre-slaughter handling period influence the incidence of, and therefore confound, these measures. Ekstrand (1998) reported the range for DOA is typically 0.1 to 0.6%, and for rejects/downgrades is very wide at 0.5 to 20%. Hall (2001) observed between 0.3 and 0.5 % of birds at slaughter with back scratches (Ross genotype). Frankenhuis et al. (1991) demonstrated that scabby hip can be caused by scratches to the

back; the incidence of scabby hip varies greatly between flocks and can be up to 60%.

Stocking density is frequently raised in discussions of broiler welfare, although the evidence is equivocal on the relationship between stocking density and welfare. Bagshaw and Matthews (2001) suggested that high litter temperatures rather than stocking density per se may contribute to poor welfare.

This study used a suite of measures to assess the welfare of broilers in NZ. Health status was assessed from the incidence of mortalities (and causes) and culls; skin disorders of the feet (Berg, 1998), hocks (Butterworth, 2002) and breasts; leg health was assessed with a gait scoring procedure (Kestin et al 1992); environmental conditions were assessed by measuring the incidence of skin disorders; and pre slaughter handling was measured from the incidence of birds dead on arrival (DOA), rejects and back scratches.

The potential influence of management factors on welfare was examined through association of management parameters (obtained in an epidemiological questionnaire) with the health and welfare measures. It was beyond the scope of the present study to measure directly the behavioural repertoire of the broilers or the effects of stocking density on welfare. The potential influence of stocking density was examined by correlating welfare measures with variations in stocking density that arose naturally during the study.

Aims: To identify appropriate welfare indicators for broilers, and apply them to quantify the welfare status of broilers in New Zealand.

At the beginning of the study, a Broiler Welfare Research Committee (BWRC) was formed (with representation from Poultry Industry Association of New Zealand (PIANZ), poultry veterinarians and representatives from the major meat chicken companies in

New Zealand, a scientist from AgResearch and an independent scientist to oversee the research programme.

METHODS

In conjunction with BWRC meetings, liaison with staff from the University of Bristol, visits to NZ slaughter plants, and attendance at a gait scoring course, protocols were prepared for the collection of data for the following measures: mortality, leg health, contact dermatitis and pre-slaughter handling and catching damage. In addition, information on management practices was collected using a questionnaire.

FARMS

The research was carried out on commercial broiler farms and within the context of the typical management of the birds.

To determine the number of sheds to study, historical mortality data was analysed to assess the most appropriate sample size (number of sheds) required to measure mortality reliably and to obtain some indication of seasonal variability in health and welfare of the birds. A shed refers to one growing cycle of a flock of broilers from placement to slaughter. These analyses indicated that, ideally, 36 sheds (one shed per farm) over the four seasons ought to be examined each year. However, for logistical reasons (i.e. availability of veterinarians, financial constraints), a total of 36 sheds only could be used in the study (12 sheds were examined in the first year, and 24 shed in the second year). Sheds were allocated to companies in proportion to the number of birds they process over the industry. Nine sheds were examined in each season, three for each season in the first year and six in the second year.

In summary, only one shed was examined on each farm in the study. A total of 36 farms/sheds were sampled over the 18 months of the study. Each shed was visited by researchers between 1 to 3 times, depending on slaughter dates for the flock. During the study a total of 85 visits to the sheds were carried out (36 sheds had one visit, and of those 32 had a second visit, and of those 17 sheds had a third visit). The experimental protocol was tested on one additional farm prior to the start of the project (these data were included in the analyses).

There were three common sets of management practice (designated A, B and C). They varied in terms of feeding, genotype, lighting regime and other factors. For commercial sensitivity reasons, these cannot be described in detail.

Kestin et al. (1992) demonstrated that a sample size of at least 250 birds per shed was required to measure reliably walking ability (leg health). In our study, samples of at least 250 birds per shed were used.

In the slaughter plant, approximately 100 birds were used to measure skin disorders (Ekstrand et al., 1998) and back scratches.

ANIMALS

There were two genotypes (breeds) used in this study, Ross and Cobb. Table 1 shows the average number of chicks, the average shed size, stocking rate and stocking density for birds of each breed for the sheds used in the study.

Table 1. Averages (across sheds) for the numbers of chicks at placement, shed sizes, stocking rates and maximum densities attained for each genotype.

Breed	Ave. number Of chicks	Ave. shed size m^2	Range of Max stocking density (kgm^{-2})	Average stocking rate Chicks m^{-2}	Average stocking density ($kgm^{-2)}$
Cobb	27235	1360	32.9-37.5	20	36.1
Ross	23368	1094	34.3-39.3	21	36.3
Average	25354	1230	32.9-39.3	21	36.2

Timing of measurements

Normal farming practice was carried out on the farms in this study. During the time a flock was in a shed, typically a proportion of the flock was removed for slaughter (thinning) once or twice (and very occasionally three times) before the remainder of the birds in the flock were slaughtered (terminal slaughter). Gait scores were measured on a sample of birds in the shed two days before a thin or the terminal slaughter. When more than two thins were

scheduled, measurements were taken for two thins only (at the first thin and a mid thin). Additional measures were taken on a sample of these birds at the slaughter plant. These measurements were contact dermatitis (foot, hock and breast), pre-slaughter handling (back scratches), dead on arrival (DOA), and reject birds.

MEASURES

Epidemiological questionnaire

A questionnaire was used to obtain information about management and husbandry practices and policies for each shed used in the study. This provided details of factors such as number and weight of chicks placed; sex; time of year; age at assessment and slaughter; stocking density, thinning practices; brooding conditions; nutritional profile; vitamin and mineral levels; litter substrates; feeder and drinker design/type; water source; lighting programmes; age of sheds; medication policy, coccidiostat usage, vaccination programmes, bird to stock person ratio; training /qualifications; biosecurity measures.

The questionnaire was completed by the grower (farm manager) on a standard form either on their own (if the questionnaire was sent to them) or in conversation with a research assistant, at the first visit to the farm, when the chicks were placed in the shed. On the second visit to the farm, growers were asked a set of follow up questions specifically related to the management of the shed used in this study.

MORTALITY

Birds that died on days 1, 3, 5, 7, in the first week, and thereafter once per week (e.g. day 10 in week 2, day 17 in week 3) were kept for post mortem (PM) examination. Birds that died in the shed (“natural death”) were distinguished from those that were culled. Birds that were culled were separated into two groups; leg culls and other culls. The grower ascribed reasons for culling the birds. Leg culls were birds that were perceived to have a walking ability

problem by the grower, whereas other culls were birds with problems other than leg weakness.

It was agreed to adapt the criteria for cause of death from the procedure used by one of the poultry veterinarians in his commercial practice. The mortality descriptions were agreed by all the veterinarians involved in the study, and a booklet containing a list of common pathologies, detailed descriptions and colour photographs was completed. This booklet was made available to all personnel undertaking post-mortem analyses (and is available on request).

For logistical reasons, it was decided that all dead birds would be frozen prior to examination to allow the autopsies to be carried out as time permitted by the veterinarians involved. However, one veterinarian subsequently found it was not possible to follow this policy and conducted 55% of his autopsies on fresh birds.

Leg heath

Gait scoring

Leg weakness was assessed using a recognised method developed by Kestin et al. (1992), which comprises a 6 point gait scoring system (scores of 0 to 5, with 5 being the poorest gait). Techniques developed in the Bristol study were used to train observers. Dr Andy Butterworth ran a course on gait scoring at Ruakura for scorers in the present study and representatives from the poultry industry prior to the start of the study. In addition, similar to the Bristol study, the reliability of gait scoring ability by the assessors was monitored by regular independent assessment of observers scoring standard video taped sequences. Consistency of individual scoring and degree of agreement between scorers (reliability) was undertaken prior to and twice during the study.

On the farm visit a gait scorer and recorder would gait score 250 birds, selected at random within one shed, by reference to a pre

randomised location identifier. Birds were selected from 10 locations, in groups of 25 to 30, by corralling at each location using a hinged catching pen. Each bird was individually encouraged to walk out of the pen and was scored as it did so.

CONTACT DERMATITIS

Standard photographs were used to describe the scoring system for each type of dermatitis (foot pad, hock burn, breast blisters). Back scratches were assessed according to number present (see below). Consistency of individual scoring and degree of agreement were obtained for each measure before and during the study for all observers.

The sample of birds scored for hock burn, breast blisters and back scratches were assessed after plucking and prior to evisceration. Once the feet had been removed (after plucking and evisceration), 50 right feet and 50 left feet were randomly collected for scoring foot pad dermatitis.

Foot pad dermatitis

The foot pad dermatitis scores were on a five point scale of 0 (no foot pad dermatitis) to 4 (severe foot pad dermatitis).

Hock Burn

The hocks were assessed on a four point scale (0 to 3). Ranging from 0 (no hock burn) to 3 (severe hock burn).

Breast blisters (blisters)

Breast blisters were given a score of 0 (no breast blisters), 1 (presence of breast blisters). There was no account taken of the size of the breast blister.

PRE-SLAUGHTER HANDLING

Back Scratches

Scratches longer than 2.5 cm were scored according to the following scale: 0 (no scratches); 1 (1 to 2 scratches); 2 (3 or more scratches). No account was taken of age or depth of scratch. A marker 2.5 cm in length was held up near the bird being scored to assist observers to make their assessment of the length of the scratch. Consistency of individual scoring and degree of agreement were obtained for each measure before and during the study for all observers.

Dead on arrival (DOA) and rejects

The number of DOA and rejects for each shed were taken from the slaughter plant records.

Rejects

Birds that were rejected as part of normal company policy were collected and ascribed a cause of death using the definitions described previously on farm mortalities.

STATISTICAL ANALYSES

The data analysed were welfare measures (response data) and epidemiological survey information, which were put into a model to identify significant correlations between the two. Correlations between welfare measures were also assessed.

RESPONSE DATA

Because there were large age and live weight differences between thins, on different farms, and these clearly affected the measures of gait score and contact dermatitis, the gait and contact dermatitis scores were estimated on a farm basis adjusting for age differences using a linear mixed model. In this model, the thins were split into 3 age groups with farms modelled as a random effect. The adjusted farm effects were the best linear unbiased predictors (BLUPs) from the model. Scorer was included in the model. The contact dermatitis data, except for breast blisters, were not normally distributed, so for these variables, the data were log-transformed.

EPIDEMIOLOGICAL SURVEY DATA

Some of the responses to particular questions were the same for most farms, or for all farms within a common type of management practice. This precluded their use as potential explanatory variables. The remaining variables were used in multiple regression models to determine which combination showed the best association with each welfare measure taken on the farm or slaughter plant.

THE MODEL

The model included season, stocking rate, stocking density, genotype (breed) and management practice (which includes factors such as nutrition, lighting schedules, and genotype). Only those factors which were statistically significant will be presented.

BLUP analyses were used to identify the linkage of welfare measures to management practices. With a study such as this a large number of statistical tests have been carried out, which increased the likelihood that one or more of these would produce a significant result merely by chance. Results of borderline significance should be interpreted with caution. For this reason, only those associations (BLUPs) where $p < 0.01$ are presented.

The R^2 value measures the proportion of the variance in the response variable (welfare measure taken on the farm or slaughter plant) explained by the explanatory terms (responses to the questionnaire). Because of the nature of the data and the analytical techniques are correlational we cannot infer any causal relationship between the response and explanatory variables.

TRAINING DATA

Differences between scorers were tested using an analysis of variance for each of the response variables used in the main study.

RELIABILTY

There were no significant differences between scorers for gait score and they were consistent over time. The gait scorers were on average scoring 0.15 of a score less than the reference scores from Bristol University.

For the measures of dermatitis and back scratches, the individual scorers were consistent over time and were not significantly different from each other.

Two of the veterinarians who completed 45% of the autopsies agreed 98% of the time. The agreement between all three veterinarians was 70%, which was deemed acceptable for the purposes of this study.

RESULTS

We firstly describe husbandry procedures that were common across farms, then practices that differed, then data on the welfare measures, then present significant correlations between welfare measures and the husbandry procedures.

COMMON HUSBANDRY PROCEDURES AND WELFARE MEASURES

A number of factors were common to the majority of the farms studied. Most farms had smooth concrete floor (94%), the remaining 6% had bitumen or wooden floors. The ventilation systems on all farms had air extracted not blown into the shed. All sheds used pans to feed the chickens, and the lines between the pans were emptied out and the pans were disinfected before each new flock entered the shed. Most farms had nipple drinkers (93%), which were fed by bore water (83%), with chlorine added to the water (86%). A manual weighing system was used to weigh birds (94% of farms). All farms had a formal rodent control policy. The sheds were washed and disinfected before the placement of a new flock on all farms, and the majority of growers applied the disinfectant with a spray (86%). Growers either replaced or laundered their work clothes (86%) and replaced or cleaned and disinfected their boots (97%) prior to the placement of a new flock. Trafficked and non-trafficked areas outside the shed were very clean (97% sheds). The cleanliness outside the shed deteriorated on some farms by the second visit (first thin), with 72% of farms having very clean trafficked areas, and 66% farms having very clean non-trafficked areas. Most growers changed their boots before entering the shed (86%) on the first visit (when the birds were placed in the shed), however by the second visit (first thin) fewer growers changed their boots before entering the shed (64%).

For all farms, feed was supplied to the growers from company feed mills, and all of the feed contained antibiotics (100%) and

enzymes. For all flocks feed was provided *ad libitum* to chicks less than 7 days old. The majority of flocks were not vaccinated at the hatchery (83%) or the farm (94%). Eight percent of the 36 study farms examined were diagnosed with a disease (such as E.coli.) during this study. All sheds had automated lighting systems.

Wood shavings were used in all of the sheds, there was no new litter added before the first thin, and in a few sheds (16%) litter was added before the second thin.

At the first thin, 14% of sheds examined had system failures and another 8% of sheds had system failures by the second thin (e.g. 3 sheds had a feeder line failure, and 2 sheds had water leaks). There were no behavioural enrichment devices provided for the chickens in any of the sheds.

As there was so little variation in these procedures across farms, no correlation between them and welfare measures was expected, and none was found. There were many other husbandry procedures which varied between farms. Correlational analyses between these procedures and the welfare measures were under taken and the results are described when there was a significant effect detected.

WELFARE MEASURES AND CORRELATION WITH HUSBANDRY PROCEDURES

Incidence of mortality

A total sample of 35,892 deaths was recorded by the growers for the flocks studied. Averaged over all the farms, the percentage mortality was 3.8%, the percent of birds that died of ‘natural causes’ was 2.7%, the percent of birds that were culled due to leg weakness (leg culls) was 0.3% and the percent of birds that were culled for reasons other than leg weakness (other culls) was 0.8%.

Farm mortality and Post mortem examination birds

Cause of death data are presented from 31 of the farms (there were no data from five of the farms (4 out of 6 farms for management type A) due to unforeseen technical reasons. The post-mortem information comprised data for 6503 birds (18% of the recorded farm deaths). Post-mortems were carried out on 14.8% of 'natural' farm deaths, 23.6% of leg culls and 27.5% of other culls. Table 2 shows percentage of weekly farm deaths by type of death. Overall, 71% of autopsied birds died of natural causes, 8% were leg culls and 21% were other culls (Table 2). These figures did not vary much from week to week, but leg culls were higher and other culls lower over the last three weeks..

Table 2. Percentage of weekly farm deaths by type of death

	Week 1	**Week 2**	**Week 3**	**Week 4**	**Week 5**	**Week 6**	**Week 7**	**Average over grow out**
"natural deaths"	69%	73%	74%	72%	72%	70%	74%	71%
Leg culls	6%	7%	8%	8%	12%	13%	14%	8%
Other culls	25%	20%	18%	20%	16%	16%	11%	21%
Total	100%	100%	100%	100%	100%	100%	100%	

Of the birds that died over the 7 weeks of the flocks' life (grow-out period), most occurred in the 1st week of life (35%), with only 3% of all deaths occurring in the 7th week of life (Table 3). Of all the birds that died of 'natural' causes 34% died in the first week. Similarly, 24% and 42% of all leg culls and other culls, respectively, died in the first week. The proportions of deaths in each category in the seventh week were 3, 5, and 2% for natural deaths, leg culls and other culls, respectively.

Table 3. Percentage of each mortality type ('natural' deaths and culls) occurring in each week of the grow-out period.

	Week 1	**Week 2**	**Week 3**	**Week 4**	**Week 5**	**Week 6**	**Week 7**	**Total**
"natural deaths"	34%	18%	15%	12%	11%	7%	3%	100%
Leg culls	24%	16%	13%	13%	17%	12%	5%	100%
Other culls	42%	18%	12%	12%	9%	5%	2%	100%
Average mortality	35%	18%	14%	12%	11%	7%	3%	100%

Note: Culls are birds removed by grower; average mortality is average of ‘natural deaths and culls.

Table 4 shows the 10 most frequent causes of death in the autopsies of ‘natural deaths. The highest percentage of deaths was attributed to acute death syndrome (ADS) (17.6%). The percentage of birds with “no diagnosis” was 11.43%. The second highest cause of death was attributed to navel infection (9%) (Table 4).

Table 4 Top 10 causes of death for the autopsied birds of natural deaths

Post mortem condition	**% of birds autopsied**
Acute Death Syndrome	17.6
No Diagnosis	11.4
Navel Infection	9.0
Cull Runt	8.8
Non Starters	7.8
Colisepticaemia	7.2
Other	6.0
Infected Yolk Sac	5.8
Visceral Gout	4.8
Too Decomposed	3.2

Table 5 shows the percentage of all birds (live and dead) autopsied in the study affected by each condition. The percent of birds dying from the two highest ranking conditions were acute death syndrome at 0.69% navel infection at 0.35%.

Table 5. The percentage of all birds in the study affected by each condition

Autopsy condition	**Number of autopsies**	**Overall %**
Acute death syndrome	1141	0.69
No diagnosis	743	0.45
Naval infection	583	0.35
Cull runt	574	0.35
Non starters	510	0.31
Colisepticaemia	467	0.28
Other	390	0.23
Infected yolk sac	375	0.23

Gout	315	0.19
Ascites	199	0.12
Twisted leg	175	0.11
Femoral head necrosis	140	0.08
Cull no obvious abnormality	138	0.08
Trauma	103	0.06
Joint infection	83	0.05
Others	61	0.04
Kinky back	47	0.03
Dehydration	45	0.03
Pasty vent	27	0.02
Pecked	40	0.02
Impacted bowel	35	0.02
Legs other	33	0.02
Infection (other)	24	0.01
Abnormalities	15	0.01
Cellulitis	9	0.01
Pendulous crop	8	0.00
Hepatitis	7	0.00
Rickets	3	0.00
Septicaemia	3	0.00
T.D.P.	2	0.00
Osteomyelitis	2	0.00
Liver absess	1	0.00
Flks	0	0.00
Enteritis	0	0.00
Cholangiohepatitis	0	0.00

Correlations between cause of death and husbandry procedures

Acute Death Syndrome

The correlations between cause of death and husbandry procedures are presented for the two most common causes only (as the rates of occurrence of the other causes were too small to be useful in the model).

Husbandry procedures which were correlated with acute death syndrome were: hock burn (Figure 1); the number of days the birds were fed diet 1 (the food the birds were fed for the first few weeks of the grow out period) (Figure 2); and use of foot baths by growers in the annex to the sheds (Figure 3). These three variables accounted for 41% (R^2) of the variability (p = 0.0059).

There was an increasing incidence of ADS with increasing average hock burn score.

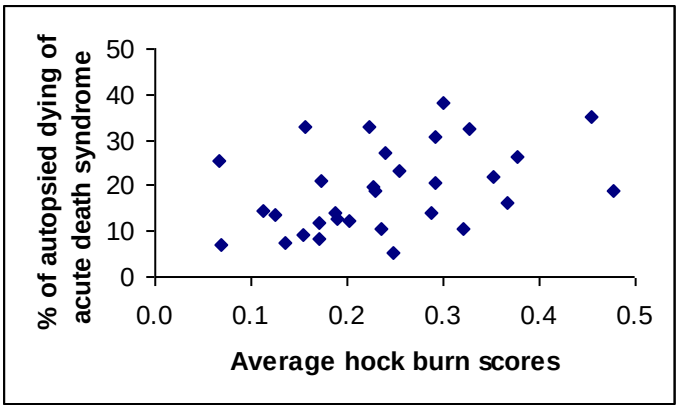

Figure 1 Percentage of autopsied birds that died of acute death syndrome versus average hock burn scores

The trend was for fewer deaths ascribed to ADS with increasing time on diet 1.

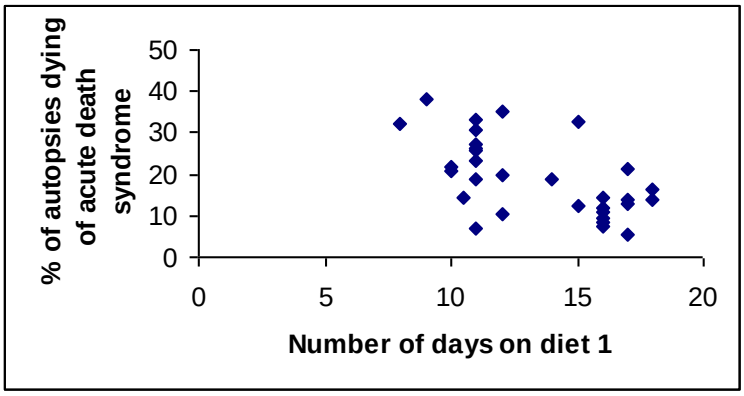

Figure 2 Percentage of autopsied birds that died of acute death syndrome versus number of days fed on diet 1.

In those farms with a foot bath in the annex, there appeared to be less ADS compared with farms were there was no foot bath in the annex.

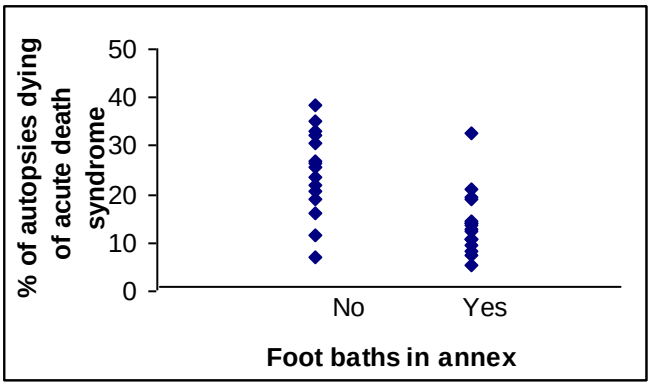

Figure 3 Percentage of autopsied birds that died of acute death syndrome versus the use of foot baths in the annex of the sheds

Navel infection

Husbandry procedures that were correlated with navel infections were the type of ventilation system used in the shed, and the genotype of the bird. These two variables accounted for 64% (R^2) of the variation ($p < 0.001$).

Sheds with cross flow ventilation had lower percentages of navel infection compared with sheds with other types of ventilation systems (Figure 4).

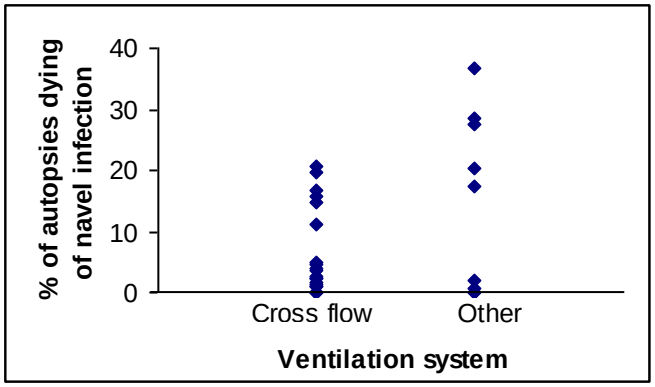

Figure 4 Percentage of autopsied birds that died of navel infection versus ventilation system

While genotype was correlated with death rate due to navel infection, this factor (genotype) is inextricably confounded with other aspects of the management practices associated with particular genotypes. Thus, navel infection death rates are presented as a function of management practice (Figure 5). Management practice C had a lower percentage of navel infection compared with management practices A and B.

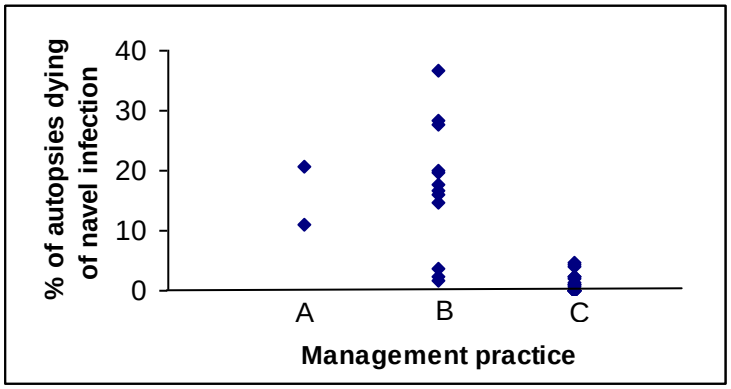

Figure 5 Percentage of autopsied birds that died of navel infection versus management practice

Incidence of leg weakness

Of the birds culled on the farm (0.3% of all birds) ostensibly due to a leg problem (refer to Table 2 for percentage of birds each week), over a quarter (28%) of the birds (Table 4) could not be ascribed a "cause of death" (other than culling) using the post-mortem techniques and criteria used in this study. Just less than a quarter of birds (24%) culled for leg problems were ascribed as having twisted legs, 10% joint infections, 9.5% femoral head necrosis and 6.2% as having spondylolisthesis (kinky back) (Table 6).

Table 6 Top 10 conditions associated with leg culls on the farm

Condition	**% of leg culls**
No Diagnosis	28.1
Varus valgus deformity (sp) and twisted tibia	24.1
Joint Infection	10.1
Femoral Head Necrosis	9.5
Spondylolisthesis (Kinky Back)	6.2
Legs Other	4.3
Colisepticaemia	3.3
Trauma	2.7

Acute Death Syndrome	2.2

The factors from the epidemiological survey which were correlated with percentage of birds culled for leg problems were genotype and target temperature at week 3 (R^2 = 48%) (p < 0.001). As already mentioned, genotype is confounded with other management practices. Variation in leg culls is, thus, presented as a function of management practice (Figure 6).

The percentage of autopsied birds that were culled due to leg weakness was highest with management practice A.

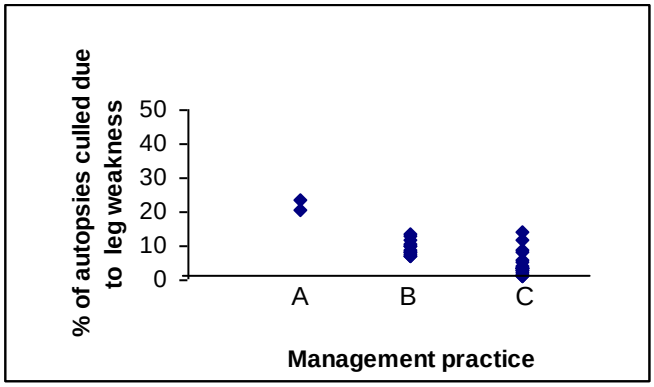

Figure 6 Percentage of autopsied birds that were culled due to leg weakness versus management practice

The graph of percentage of autopsied birds that were culled due to leg weakness (leg culls) against target temperature at week 3 (Figure 7) shows two outlier points (sheds). The birds in these two sheds had a higher percentage of leg culls with lower than average target temperature at week 3, compared with the other sheds in the study. Further, these two sheds were the only data in this data set for management practice A.

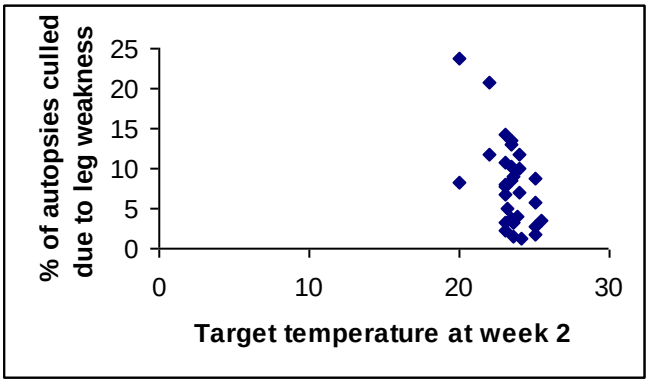

Figure 7 Percentage of autopsied birds that were culled due to leg weakness versus target temperature at week 3.

Gait score

Gait scorers in this study scored within half a score of each other, and scored similarly to Bristol University standards (our scorers were on average 0.15 of a score less than the Bristol reference score).

The average flock gait score across all farms and all live weight groups was 2.14.

Gait score is shown by live weight category (live weight group 1, 1.64 to 1.99kg; live weight group 2, 2.06 kg to 2.89 kg; and live weight group 3, 2.94 kg to 3.53 kg) in Figure 8. The average percentage birds with gait score 0 was 0.1% for live weight group 1, and 0.0% for groups 2 and 3. Over the three live weight groups, the majority of the birds had gait scores 1 or 2 (75.6%). The percentage of birds with gait score 2 were 70.1%, 66.4% and 62.7% for groups 1, 2 and 3 respectively ($p < 0.01$).

There were also significant differences between the live weight groups ($p < 0.001$) in percentage of birds with gait scores in categories 1, 3 and 4. The lightest birds (group 1) showed a higher percentage of gait score 1 (16.5%) compared with heavier birds (group 2, 3%; group 3, 0.6%). In contrast, heavier birds, had a higher percentage in gait score 3 (group 2, 29%; group 3, 34%) compared with lighter birds (group 1, 12%) ($p < 0.001$). There were very few birds with a gait score of 4 (1.3%, averaged over the three live weight groups). The highest percentage with gait score 4 occurred in group 3 (2.3%) ($p < 0.001$). The corresponding percentages for groups 1 and 2 were 0.4% and 1.7%, respectively. The percentages of birds with gait score 5 in each weight category was 0.1%. There was no difference between the live weight groups in the percentage of birds with gait score 5 (average 0.1%).

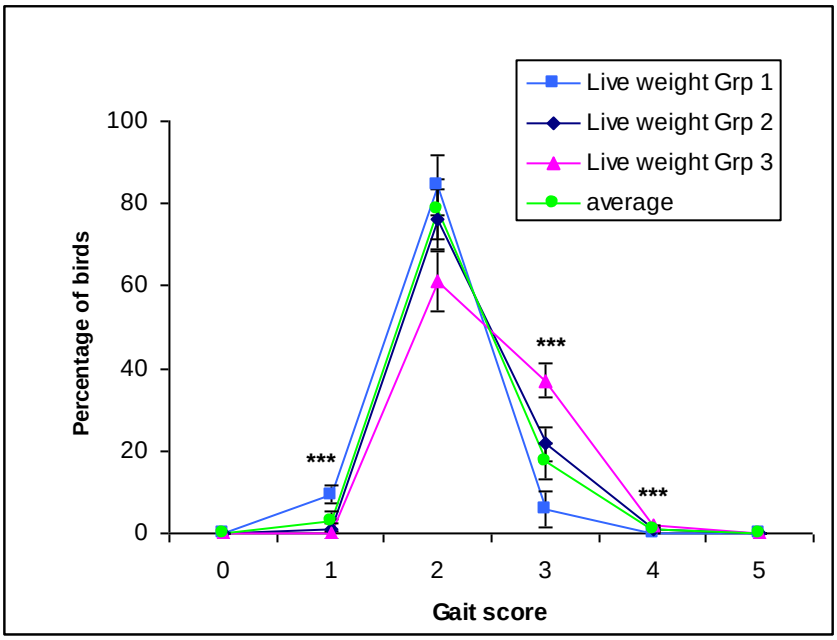

Figure 8 Percentage of birds by gait scores in 3 live weight groups

Note: * = p < 0.05; ** = p < 0.01; *** = p < 0.001; sed are shown for each data point. Live weight group 1, 1.64 to 1.99kg; live weight group 2, 2.06 kg to 2.89 kg; and live weight group 3, 2.94 kg to 3.53 kg

There were no significant correlations between husbandry factors and gait score.

Incidence of contact dermatitis

Foot pad dermatitis scores

The average foot pad dermatitis score was 0.37. On average, 71% of birds had no foot pad dermatitis, 89.5% had scores of 0 or 1, and 97.9% had scores of 0, 1, or 2. A higher proportion of the heaviest birds (live weight group 3, 83.7%) had a score of 0 compared with the lighter birds (live weight groups 1 and 2, mean 68%) ($p < 0.05$). In contrast, lower proportions of the heaviest birds had scores of 1 (12.9%) or 2 (2.6%) compared with lighter birds (score 1: live weight group 1, 21.9%; live weight group 2, 17.9%) ($p < 0.01$); score 2: live weight group 1, 9.9 %; live weight group 2, 9.5%) ($p < 0.01$). Figure 9 shows the percentage of birds across foot pad dermatitis scores in each live weight group.

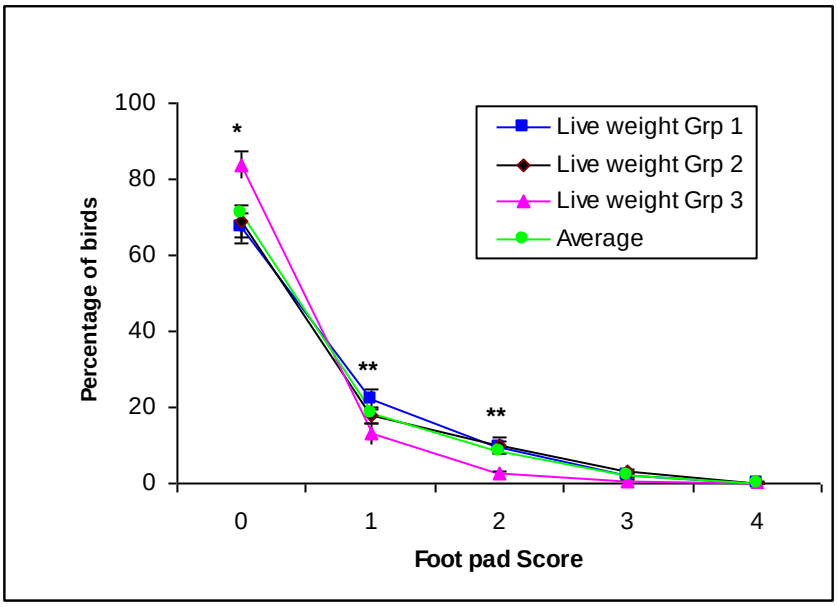

Figure 9 Percentage of birds by foot pad scores in 3 live weight groups

Note: * = p < 0.05; ** = p<0.01; *** = p<0.001, sem's are shown for each data point Live weight group 1, 1.64 to 1.99kg; live weight group 2, 2.06 kg to 2.89 kg; and live weight group 3, 2.94 kg to 3.53 kg

The factors from the epidemiological survey which were correlated with foot pad dermatitis scores were; hock burn, season, and system failures. These variables accounted for 55% (R^2) ($p < 0.001$) of the variation. Birds with little foot pad dermatitis also had low hock burn scores (Figure 10).

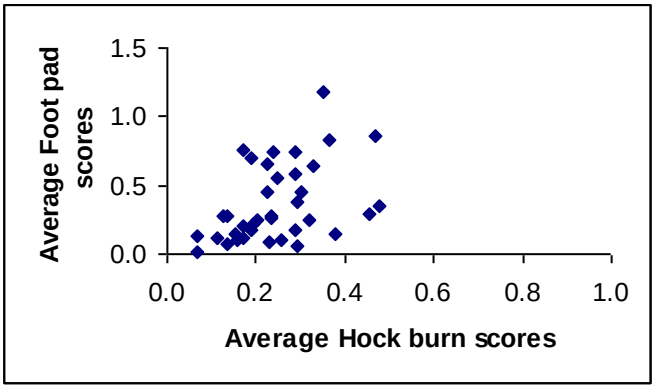

Figure 10 Foot pad dermatitis versus hock burn scores

Foot pad dermatitis was correlated with system failures in the shed. Over the study, there were five system failures, four of which

showed high foot pad dermatitis scores. Of these four system failures, three were feed line faults and one was a water line leak. Birds in one shed with a system failure giving a large water leak had a low incidence of foot pad dermatitis (Figure 11)

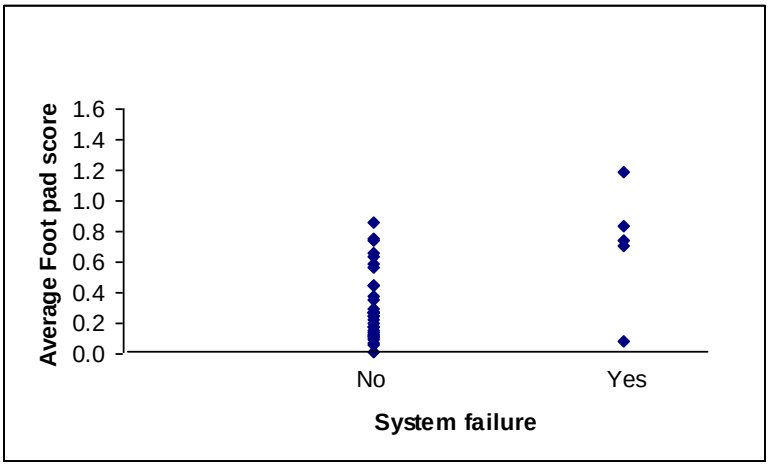

Figure 11 Foot pad dermatitis scores as a function of incidence of system failure in the shed

Season was associated with foot pad dermatitis score, with scores in winter/spring being higher than summer/autumn (Figure 12).

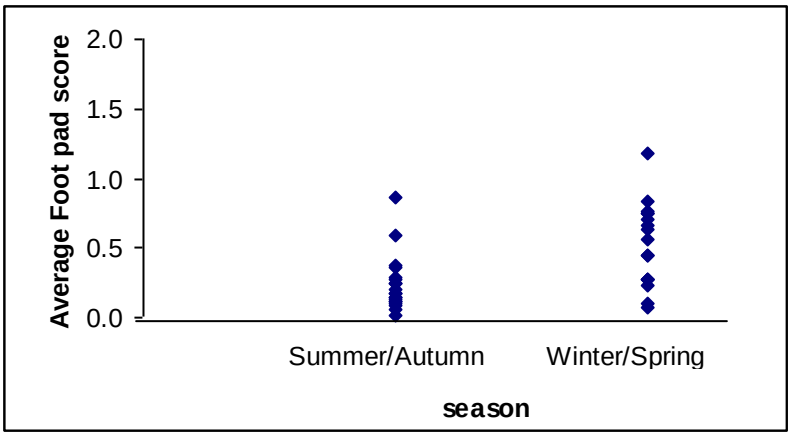

Figure 12 Foot pad dermatitis scores versus season

Hock Burn

Average hock burn scores were less than 0.5 on a scale from 1 (mild) to 3 (severe). On average, 72.4% of birds had no hock burn,

97.3% had a score of 0 or 1, and 99.9% had a score of 0, 1 or 2. There was no difference in hock burn between the three live weight groups for none (0), mild (1) or severe (3) hock burn scores. There was a higher proportion of birds with hock burn score 2 in the medium live weight group (group 2, 2.06 kg to 2.89 kg) compared with lightest birds (group 1, 1.64 to 1.99kg) ($p < 0.001$). Figure 13 shows the hock burn scores for birds within each of the three live weight groups.

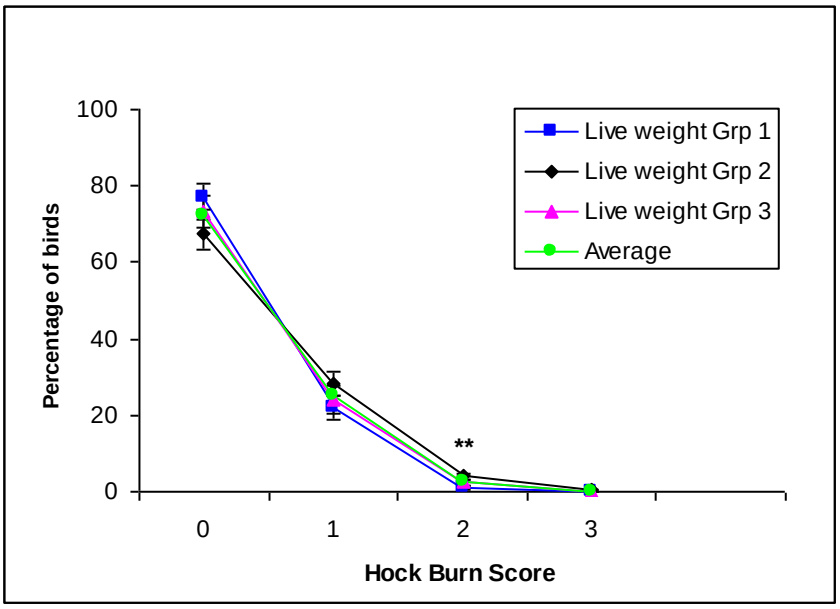

Figure 13 Percentage of birds by hock burn scores in 3 live weight groups

Note: * = p < 0.05; ** = p<0.01; *** = p<0.001, sem's are shown for each data point Live weight group 1, 1.64 to 1.99kg; live weight group 2, 2.06 kg to 2.89 kg; and live weight group 3, 2.94 kg to 3.53 kg

The factors from the epidemiological survey which were correlated with incidence of hock burn were: foot pad dermatitis (see Figure 10); brooding method in the shed; the subjective description of air quality and chicks m^{-2}. These four variables accounted for 57% (R^2) of the variation in the model ($p < 0.001$).

Average Hock burn scores were higher in sheds were there was half shed brooding, compared with two thirds, three quarters or full shed brooding (Figure 14).

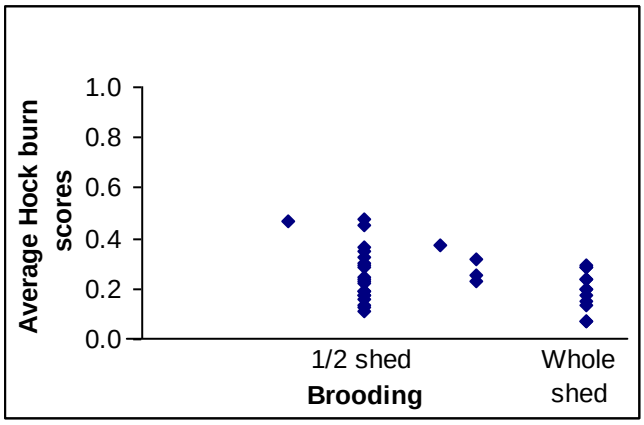

Figure 14 Hock burn scores versus brooding method used in the shed

Farms with “very good” or “average” air quality was associated with low average hock burn scores, whereas “good air quality” was associated with relatively higher average hock burn scores (Figure 15)

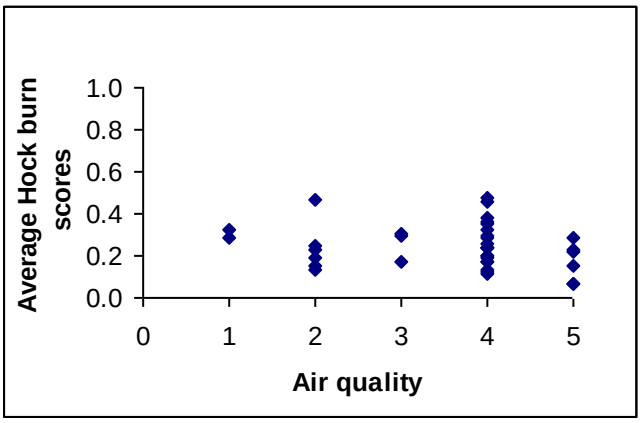

Figure 15 Average hock burn scores versus air quality

Note: 1 = smelly; 2 = dusty; 3 = average; 4 = good; 5 = very good

Hock burn scores appear to increase with increasing number of chick per metre square (Figure 16)

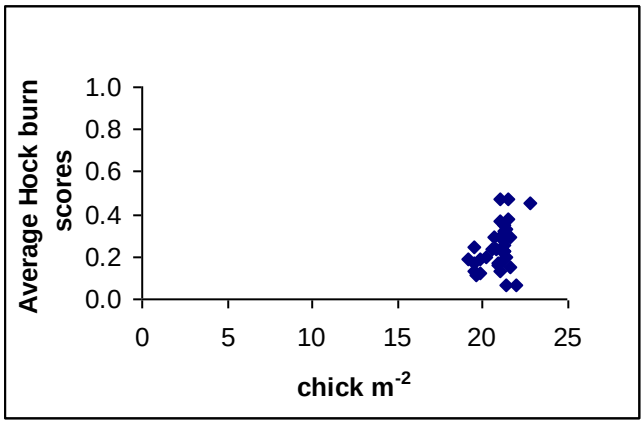

Figure 16 Hock burn scores versus chicks per m^2

Breast blisters

On average 99% of birds had no breast blisters (score = 0) (Figure 17). There were no differences between the live weight groups.

Figure 17 Percentage of birds by breast blister scores in 3 live weight groups

Note: * = p < 0.05; ** = p<0.01; *** = p<0.001, sem's are shown for each data point Live weight group 1, 1.64 to 1.99kg; live weight group 2, 2.06 kg to 2.89 kg; and live weight group 3, 2.94 kg to 3.53 kg

Factors in the epidemiological survey were not associated with the percent of birds with breast blisters.

Incidence of back scratches, DOAs (birds dead on arrival) and rejected birds.

Back scratches

The average back scratch score was 0.64. On average, 59.4% of birds had no back scratches, 91.2% had a score of 0 or 1. The majority of birds with no back scratches were in the heaviest live weight group (75%), while less than half of the lightest birds had no back scratches (44.2%) ($p < 0.001$). A higher proportion of the lightest birds had scores of 1 (41%) and 2 (14 %) compared with live weight group 2 (score 1, 34% and score 2, 6.9%) and live weight group 3 (score 1 22%; score 2 2.5%) ($p < 0.001$). Figure18 shows the back scratch scores for birds within each of the three live weight groups.

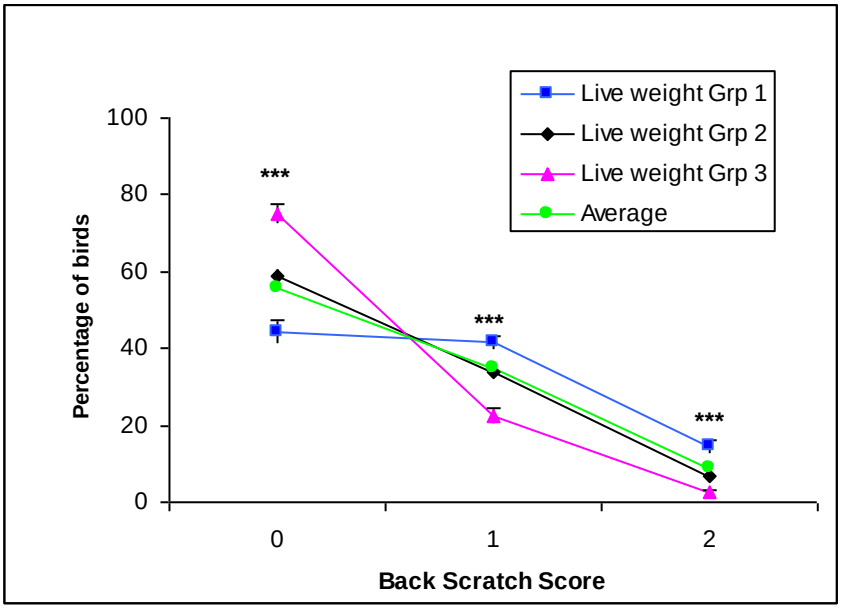

Figure 18 Percentage of birds by back scratch scores in 3 live weight groups

Note: * = p < 0.05; ** = p<0.01; *** = p<0.001, sem's are shown for each data point. Live weight group 1, 1.64 to 1.99kg; live weight group 2, 2.06 kg to 2.89 kg; and live weight group 3, 2.94 kg to 3.53 kg

Factors in the epidemiological survey which were correlated with back scratches were: season; management practices; and the material used to construct the shed. These three variables accounted for 38% (R^2) of the variation in the model ($p = 0.0075$).

Management practice A had higher back scratch scores than B and C (Figure 19).

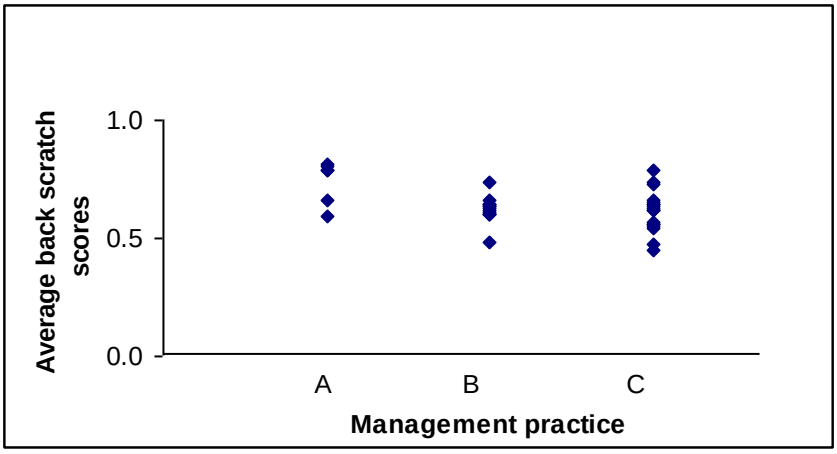

Figure 19 Average back scratch score across management practices

Average back scratch scores were higher in winter/spring compared with summer/Autumn season (range from 0.43 to 0.79) compared with the winter/spring season (range from 0.54 to 0.78) (Figure 20. All female sheds had a lower average back scratch score compared with as hatched (mixed gender) or all male sheds).

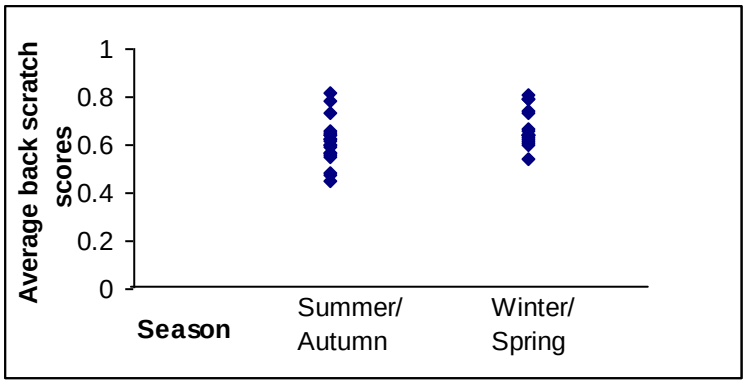

Figure 20 Average back scratch score across season

Back scratch scores were higher in sheds with wooden framing (Figure 21).

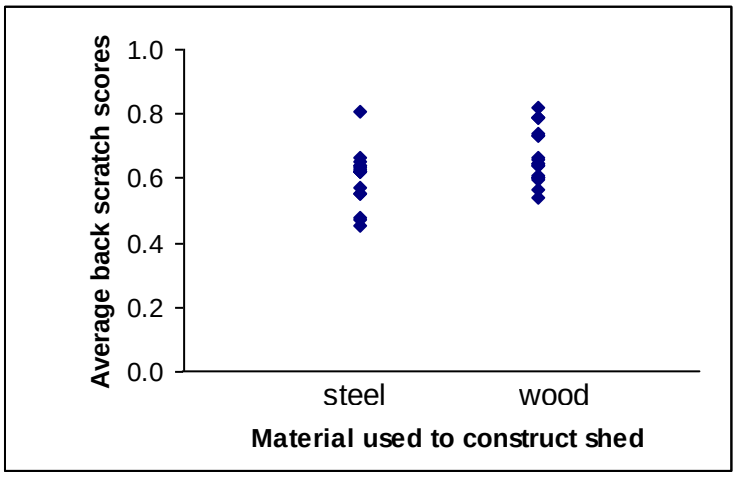

Figure 21 Average back scratch score by construction material of shed

Birds dead on arrival (DOA) and rejected birds (rejects)

Table 7 shows the percentage of birds dead on arrival (DOA) or rejected at the slaughter plant for each live weight group. The average proportion of birds dead on arrival (DOA) was 0.15% with the heaviest birds having the highest proportion (0.20%) ($p < 0.001$). The average number of rejects was 0.22%. There was no difference in the proportion of reject birds between weight categories. The average number of DOAs and rejects combined was 0.37%, with no difference in proportions between the weight categories.

Table 7. The percentage of birds dead on arrival (DOA) or rejected at the slaughter plant by live weight group

Live weight	DOA%	SEM	Reject%	SEM	DOA & Reject%	SEM
Group 1	0.12	0.03	0.22	0.04	0.34	0.06
Group 2	0.16	0.02	0.23	0.06	0.39	0.06
Group 3	0.20	0.04	0.18	0.03	0.38	0.04
Average	**0.15**	**0.02**	**0.22**	**0.03**	**0.37**	**0.04**

Note: SEMs are shown for each data point. Live weight group 1, 1.64 to 1.99kg; live weight group 2, 2.06 kg to 2.89 kg; and live weight group 3, 2.94 kg to 3.53 kg

Factors in the epidemiological survey were not associated with the percent of birds dead on arrival at the slaughter plant.

The factors in the epidemiological survey which were correlated with proportion of birds rejected were; hock burn, expected age of slaughter and litter depth at placement (R^2 = 42.6, p = 0.0037).

Rejection rates increased at higher average hock burn scores (Figure 22).

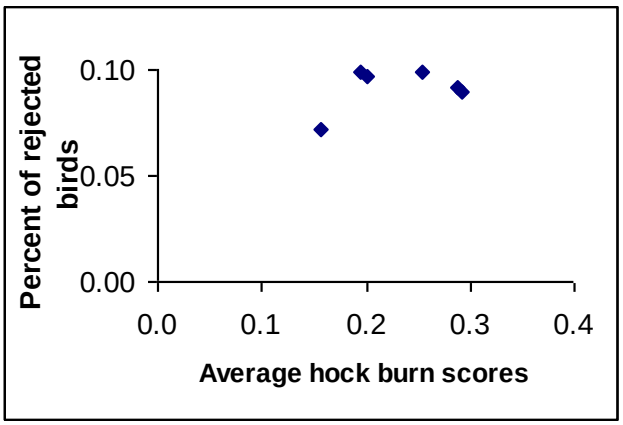

Figure 22 Percentage of rejected birds versus average hock burn scores

Percentages of rejected birds increased with increases in expected age of slaughter (Figure 23).

Figure 23 Percentage of rejected birds versus expected age of slaughter

Percentages of rejected birds increased with litter depth at placement (Figure 24).

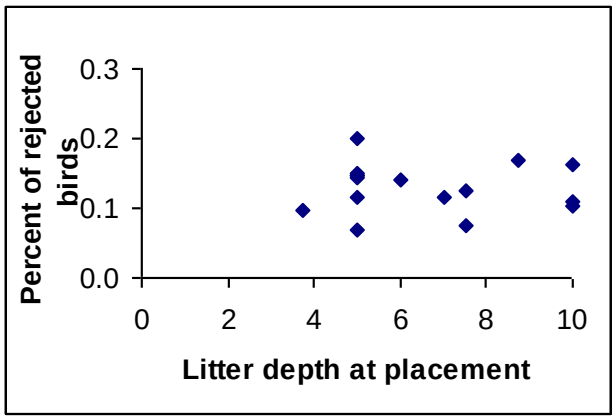

Figure 24 Percentage of rejected birds versus litter depth at placement

DISCUSSION

This study has used the best measures available to objectively assess the management and welfare of broiler chickens in New Zealand, and establishes a baseline for welfare standards in the industry.

Some of the husbandry procedures are common across the industry, include: type of flooring (concrete); and litter type (wood shavings); ventilation system (extraction); use of pans for feeding and nipple drinkers; rodent control; hygiene policies; types of and frequency of use antibiotics; and enzymes added to feed; type of feed available to chicks less than 7 days old; and absence of specific behavioural enrichment strategies.

Variations in the welfare measures recorded in the present study were correlated with each other and with variations in the procedures identified in the epidemiological survey. It is important to remember that some of the significant correlations may have occurred by chance, and if a reasonable (logical) explanation cannot be found for the correlations, it is not sensible to attribute them any significance. That said, these results remain useful in identifying potential causes of variation in the welfare status of broilers.

Overall mortality was 3.8%, which is at the lower end of levels typically seen in the industry overseas, and a little higher than the best that has been reported (Butterworth, 2004). Of all the birds in the study, 0.3% died as leg culls. The contribution of leg culls to total mortality was relatively low (8%) and about half that reported for birds in two recent UK studies (15% in UK) (Hall, 2001, Dawkins et al. 2004). Further, the proportion of birds with severe leg weakness (gait score 4 and 5) in our NZ research was about one quarter that reported for broilers in the UK, Denmark and Sweden (1.4% versus 5 to 6.5%; Kestin et al. 1992; Sanotra et al. 2003). Moreover, these studies are the only published ones that have used the same gait scoring procedure as used in our

research. Considering both the leg culling and gait scoring information together, our results demonstrate that leg health in New Zealand broilers is better than for birds in Europe.

In the UK studies mentioned above, there appears to be a higher proportion of “other culls” (35% UK versus 21% NZ) and a lower proportion of “natural deaths” (50% UK versus 71% NZ) relative to total mortality compared with the New Zealand industry. This suggests that there are differences between NZ and the UK not only in leg health, but also in the conditions leading to culling for non-leg related disorders and/or natural deaths. The post-mortem data can potentially provide insights into likely differences in non-leg related conditions between NZ and elsewhere but, unfortunately, there are no other studies with appropriate autopsy data to make a detailed comparison. Further, we should exercise caution when interpreting the New Zealand industry post mortem data for the natural deaths, as the proportion of birds autopsied (for natural deaths, 14%) was much lower than the proportions autopsied for leg and other culls, about 25%). Further, there were a relatively high proportion of post mortems accorded “no diagnosis” for birds in all categories (mortality, leg cull and other cull). The reason for this may have been due to the process of freezing the birds (which had to occur for logistical reasons) altering some of the internal structures, making it more difficult for an accurate diagnosis of death. In addition, histological and other examinations of tissue were not undertaken due to financial constraints of the project.

Generally speaking, the range of conditions seen in the autopsies of the natural deaths and other culls in our study is similar to that seen elsewhere (Butterworth, 2004; Julian, 2004), and the prevalence of ascites (0.12%) was similar to that quoted elsewhere (0.15%, Butterworth, 2004), whilst kinky back (0.03% NZ versus 0.3 % elsewhere), acute death syndrome (0.69% NZ versus >2% elsewhere), pendulous crop (0.00% NZ versus 0.1 % elsewhere) were lower in our study. Other diseases such as enteritis and cellulitis were rare or absent in our post-mortem samples.

Of the birds autopsied, acute death syndrome (ADS) (also known as sudden death syndrome) was the highest ranking cause of death (17.6%). Bagshaw and Matthews (2001) reported that incidence of ADS (or sudden death syndrome) may be effected by fast growth rate, nutrition and other environmental factors. In the current study, there was a lower incidence of ADS on farms with a foot bath in the annex. On those farms without a foot bath in the annex, the growers changed boots; therefore it is unlikely that hygiene was a factor in incidence of ADS. Indeed, the presence of a foot bath cannot be assumed to reduce ADS from this study. The significance of the correlation between ADS and hock burn score is not clear, particularly since factors usually associated with hock burn (e.g. density and season (Imaeda, 2000) were not correlated with ADS. The lower rate of ADS with increased time on diet 1 could be an area for further fruitful research.

Of the birds autopsied, 9% died from navel infection. The percentage of birds with navel infection was correlated with genotype and ventilation system in the shed. There were higher percentages of birds which were autopsied with navel infections under management practice types A and B compared with type C. The difference between management practices is likely due to factors which are highly confounded such as nutrition, lighting schedules, stockmanship, and genotype. Further exploration of the differences in management practices between the three systems might yield useful information on ways to reduce the incidence of navel infection. Navel infection was generally lower in cross-flow ventilation sheds compared with other types of ventilation in sheds (e.g. roof, side and tunnel). However, there were insufficient numbers of any other types of ventilation system to make a direct comparison between different systems.

The high rate of non diagnosis of pathologies for the leg culls (28%) implies that we should exercise caution when interpreting these data. Of the leg culls autopsied, the most common pathology identified was deformed limbs (Varus valgus and twisted tibia) (24%), with the next three most common conditions being infections (joint (10%) and femoral head necrosis (9.5%)) and

kinky back (6%). These pathologies are typical of those seen elsewhere, but the relative frequency of the infectious causes appears lower in the New Zealand birds than elsewhere (e.g. femoral head necrosis rates in the UK of 17 to 38%; (Butterworth, 1999; McNamee and Smyth, 2000). Conversely, deformed limbs occurred relatively more often in the New Zealand industry than in the UK (11 to 14 % Butterworth, 1999; McNamee and Smyth, 2000). In absolute terms, this latter observation does not imply that deformed legs are a greater welfare problem for New Zealand birds as the culling rate for leg disorders in New Zealand is only about half or less than half that seen elsewhere (e.g. Dawkins, 2004; Hall, 2001; McNamee and Smyth, 2000).

The percentage of autopsied birds that were culled for leg weakness was correlated with type of management practice (higher in type A) and target temperature at week 3 (occurring in type A sheds). In this data set, management practice A was represented by two sheds only, therefore clear conclusions cannot be drawn from these results. However, further investigations may help to understand if there is any causal link between leg weakness and target temperature at week 3, or other specific management practices.

The gait scoring procedure used was highly reliable and consistent over time. On average, there were relatively few birds with a normal or near normal gait (8.1%, gait scores 0 and 1 combined), with two-thirds having a gait score of 2, 23% with a gait score of 3, and 1.4% with gait scores of 4 or5). There was a clear effect of live weight on gait score, with proportionately fewer of the heaviest (also older) birds in categories 1 and 2, and proportionately more with gait scores 3 and 4. Kestin et al. (2001) has also reported poorer gait scores with heavier birds, and demonstrated that the effect is due to weight rather than age.

A number of UK researchers (Danbury et al., 2000; Hocking et al., 1999; McGeown et al., 1999;) have attempted to assess the welfare impacts of different gait scores by measuring time budgets and determining if the degree of pain experienced varies with gait

score (see Introduction). While it would be surprising if lame birds didn't experience some pain (at least for some pathologies and particularly at high gait scores), the interpretation of these data is not unequivocal

In addition, a single gait score can be associated with a range of different pathologies (Mench, 2004) and there may be varying levels of pain associated with different pathologies. This has also not been examined scientifically. Others have attempted to assess the welfare implications of high gait score by looking at walking speed and time budgets of animals with different gait scores (e.g. Weeks et al, 2000; Bokkers and Koene, 2004). High gait score birds walk more slowly through obstacle courses, rest for longer periods and have a reduced visitation rate to feeders and drinkers. These results suggest impaired walking ability but do not resolve the issue of the presence or degree of pain experienced. We do not know if pathologies causing a particular gait score in New Zealand broilers are the same as those causing altered gait in birds in other countries. Thus, it is difficult to know if, or what, proportion of say gait score 3 birds in New Zealand are experiencing pain (as seems likely for a proportion of gait score 3 birds in the UK). It would be instructive to conduct studies in New Zealand of gait score before and after pain relief to determine the relationship between gait score and pain in broilers under New Zealand conditions. Further, more detailed studies of the pathology leading to gait abnormalities in New Zealand broilers would provide additional insights into the likely welfare impacts caused by those pathologies.

Because both leg culling rates and the occurrence of gait scores 4 and 5 (about 1%) were relatively low in our study, it seems that severe leg weakness is less of a problem in the New Zealand industry than elsewhere. As birds with gait scores 4 and 5 are likely to experience poor to very poor welfare (including pain) it is desirable to cull birds in these categories as soon as possible, thereby reducing their incidence in the flock to as close to zero as is practically possible. Research and practical management procedures to achieve this goal are a priority.

While research conducted overseas has implicated a large variety of management factors in the aetiology of leg weakness (e.g. stocking density, lighting cycles and intensity, ambient temperature and humidity, ammonia levels, litter quality and floor type; (Reiter and Bessei, 1998) no significant correlations between such factors and gait score were seen in our study. Possible reasons for the absence of correlations in the present study include: these factors do not influence leg weakness under New Zealand conditions; and/or there was too little variation in the relevant management/husbandry procedures.

Contact dermatitis is thought to be caused by a combination of moisture and chemical irritants in the litter of broiler houses (Ekstrand et al., 1998). Thus, the incidence of contact dermatitis is an indicator of the condition of litter substrate, and this in turn provides a measure of the suitability of the environmental conditions in the houses. Berg (2004) reported that a number of risk factors for contact dermatitis in temperate climates have been identified. These are: litter material; litter type; floor type; stocking density; drinker system and feed composition.

The majority (71%) of birds in this study had no foot pad dermatitis, which is similar to the levels reported in the literature (e.g. Dawkins, 2004), although it is difficult to compare directly the results from our study with others as the measurement protocols differed. Previously used protocols have been lacking in precision and not often tested for reliability and consistency in their application. In our study, an average of 89.5% of birds had scores of 0 or 1 (none or mild). These results imply that litter conditions are well maintained in NZ, although the incidence was slightly higher in winter/spring months when humidity is higher. During the winter/spring season, four of the sheds had a system failure and these birds had relatively high foot pad dermatitis. In contrast, during the summer/autumn season, one shed had a system failure these birds had relatively low foot pad dermatitis. Thus, although

the seasonal data were confounded by system failures, the higher incidence during wetter times of the year it is consistent with other studies showing that the relative humidity inside and outside the house has an influence on litter quality, with the highest prevalence of foot pad dermatitis occurring in the autumn/winter months in Europe (Berg, 2004).
The incidences of foot pad dermatitis and hock burn were correlated, as has been observed by others (Greene et al., 1985).

A higher proportion of the heavier (older) birds had no foot pad dermatitis, suggesting that this condition improves over the grow-out period. David Marks (pers comm.) suggests that this could occur as a result of an earlier bacterial infection healing over the life of the bird when litter quality is good.

The majority of birds (72%) in this study had no hock burn, which is similar to the levels reported in the literature (Menzies et al., 1998), although it is difficult to compare directly the results from our study with others as the measurement protocols differed. Previously used protocols have been lacking in precision and not often tested for reliability and consistency in their application. An average of 97.3% of birds had no or mild hock burn. These data indicate that litter conditions are well maintained in NZ. There was no difference in the percentage of birds with hock burn across the live weight groups for none, mild and severe scores. However, birds of medium weight had higher hock burn scores compared with the lightest or heaviest birds in the study. The reason for this is unclear.

Average hock burn scores were correlated with foot pad dermatitis, the type of brooding in the shed, air quality, and chick m^{-2} at placement. Average hock burn scores tended to increase with average foot pad scores and this relationship was discussed earlier. Average hock burn scores are higher in sheds where there is half shed brooding, compared with two thirds, three quarters or full shed brooding. Average hock burn scores varied little across

the subjective scores of air quality. However there appeared to be slightly lower average hock burn scores when the air quality was deemed very good (score 5). There was a trend toward increased hock burn with increased density of chicks at placement but not density at the time of assessment. There are no obvious explanations for these correlations.

The incidence of breast blisters was extremely low (0.5%), is consistent with that reported internationally (Berg, 2004), and implies that litter conditions were well maintained.

The incidence of contact dermatitis (foot pad dermatitis, hock burn and breast blisters) is similar to that reported internationally and implies that New Zealand broiler sheds have good environmental conditions. In this study, there were no correlations found between litter depth or type, floor type, or stocking density, drinker system and welfare measures. The litter material used in most sheds in our study was wood shavings, and this has been found to result in lower incidence of foot pad dermatitis compared with straw (Ekstrand et al., 1997). Nipple drinkers with cups were used in the sheds in our study, and this type of drinker system has been shown to reduce the risk of wet litter and the risk of contact dermatitis (Berg, 2004).

Back scratches, birds dead on arrival (DOA) and reject birds were used in this study as indicators of catching and other damage during the pre-slaughter period, although the activities and factors prior to this period may influence and, therefore, confound these measures.

The frequency of occurrence of back scratches is only infrequently reported in the literature, and the incidence of scratches and associated conditions varies widely from 0.3 to 60% (Hall 2001;Feddes et al., 2002; Frankenhuis et al., 1991). The average incidence of back scratches in the present study was 41%, being much higher than the lowest overseas estimates. It is not clear why

there would be such a difference, although it is possible that the low rates mentioned elsewhere are underestimates. This could occur if the measurement systems used were not reliable. For all the data reported by others,(e.g. Hall, 2001), the definitions of scratches have been imprecise and there have been, no assessments of the reliability or consistency of the scoring systems used. Thus, it is difficult to make meaningful comparisons between our data and the incidence of scratches reported elsewhere. Back scratching during the grow out period is an important welfare issue as it can lead to scabby hip syndrome and other lesions of the skin (Proudfoot and Hulan, 1985). The welfare impacts of scratches that occur during catching and pre-slaughter handling are not known, but would likely cause some pain or discomfort.

In our study, a higher percentage of lighter birds had back scratches compared with the heaviest birds. There are many factors which could contribute to this difference including stocking density (heavier birds were at a lower density due to prior thinning of a portion of the flock), feather cover (older birds have better feather cover), behaviour (older are less flighty), and gender of the bird (males are more likely to scratch and have later development of feathers). The significant correlations between back scratch incidence and management practices and season could be attributable to behavioural differences in these particular environments, but additional research would be required to ascertain any causal relationships. Average back scratch scores were correlated with the type of construction material of the shed; it is likely that this correlation occurred by chance.

The average percent of birds dead on arrival was 0.15% and the average percent of bird rejected at the slaughter plant was 0.22%, both values being at the lower end of the internationally reported levels (Ekstrand, 1998), suggesting that the pre-slaughter handling of birds in New Zealand is well conducted.

Rejected birds at the slaughter plant were correlated with average hock burn scores, expected age of slaughter and litter depth when

the chicks were placed in the shed. As average hock burn score increased there was an increase in percentage of rejected birds. However, it is important to note that the variation in hock burn scores was very small, and there were very small increases in the percentage of rejected birds (less than 0.1%). There was a trend towards increasing percentage of rejected birds with increasing expected age of slaughter, but the meaning of this is not clear as there was no relationship between live weight and reject rate. Litter depth varied from 3 to 12.5cm, but explanations for an effect of litter depth at placement on reject rates is not apparent.

Apart from a relatively high incidence of back scratches, the measures taken indicate good standards of pre-slaughter handling of broilers are achieved in New Zealand.

Stocking density and animal welfare has often been a contentious issue in the literature. Bagshaw and Matthews (2001) reported in a literature review that stocking density per se does not appear to be a major direct cause of most welfare problems, traditionally associated with high stocking density rates. From the published information it appears that other environmental conditions are more directly implicated. In this study, stocking density varied between 32.9 and 39.3 kg m^{-2}. Stocking density was not correlated with any of the welfare measures, or variables in the epidemiological survey, suggesting that broiler welfare is either unaffected by stocking density or that the range in densities seen in the current study was too small to enable correlations to be detectable. Stocking density (at the levels currently used in this study) would appear appropriate as the welfare of the birds is good.

CONCLUSIONS AND FURTHER RESEARCH

1. General flock health is good as demonstrated by the relatively low total mortality rate and low incidence of infectious pathologies in birds culled for leg disorders.

2. There is a very low rate of culling for leg disorders in New Zealand broilers and substantially fewer birds with severe leg weakness (gait score 4 and 5). Most birds had gait scores of 1 or 2. Considering both the leg culling and gait scoring information together, our results demonstrate that leg health in New Zealand broilers is better than for birds in Europe. Given the high level of international concern with leg weakness in broilers, particularly in relation to the degree of pain experienced, it would be pertinent to undertake further research on the welfare impacts at different gait scores and of the common pathologies. The frequencies of various pathologies associated with leg weakness appears different for our broilers, implying that, in order to make further research on questions such as pain relevant to our conditions, it should be undertaken in New Zealand.

3. Prevalence of all forms of contact dermatitis (footpad, hock burn and breast blisters) appears within the range reported internationally. Incidences, such as occurred, were mostly of a relatively minor nature. These data indicate that the litter in the houses is maintained in good condition, with small seasonal variation

4. Pre-slaughter handling procedures as assessed by Dead On Arrivals and reject birds were generally better than reported for other countries. The proportion of birds with back scratches averaged 39%. Meaningful comparisons between our data and the incidence of scratches reported elsewhere were not possible due to the lack details of the measurement criteria provided in other published reports. The welfare impacts of back scratches under New Zealand conditions, and procedures to reduce their incidence, would merit further study.

5. In this study, stocking density varied between 32.9 and 39.3 kg m^{-2}. Stocking density was not correlated with any of the welfare

measures, or variables in the epidemiological survey, suggesting that broiler welfare is either unaffected by stocking density, or that the range in densities seen in the current study was too small to enable correlations to be detectable. Controlled studies using a wider range of stocking densities would need to be undertaken to identify any effects of stocking density on welfare. Stocking density (at the levels currently used in this study) would appear appropriate as the welfare of the birds is good.

6. Correlations undertaken between the welfare measures and rather simple features of the husbandry system or environmental conditions revealed some significant and interesting results. Some of these appeared logical and reasonable (e.g. correlation between foot pad dermatitis and season) and provide valuable insights into possible ways to improve welfare through alteration of husbandry procedures. Variations in more complex factors such as management type (A, B, C), which includes genotype, were sometimes associated significantly with variation in welfare measures. For example, management practice type C had a higher incidence of ADS and a lower incidence of navel infection compared with the other types of management practice. This, again, suggests that there would be considerable opportunity to improve broiler welfare through identifying cause and effect relationships, such as they may exist, that underlie such correlations. It is recognised that this is not a trivial task due to the large number of highly confounded (and commercially sensitive) variables that make up, for example, a particular type of management practice.

7. One of the often-expressed concerns with intensive indoor broiler growing conditions is the lack of behavioural activity (both in the range of activities and time spent engaged in them) of broilers. The current study did not attempt to assess this aspect of broiler welfare, but we did record in the survey that there are no procedures in place to encourage a wider behavioural repertoire of birds in sheds.

8. Apart from the expected correlation between two of the measures of contact dermatitis (footpad dermatitis and hock burn), there were no significant correlations between the various welfare measures. This suggests that each measure was assessing independent welfare traits and, thus, all should be used in studies where a comprehensive description of broiler welfare status is required (e.g. in audits).
9. This study has demonstrated that the welfare of broilers in New Zealand is equal to or superior to that of broilers kept elsewhere.

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