A CONTINUOUS-CHOICE ASSESSMENT OF THE DOMESTIC FOWL'S AVERSION TO CONCURRENT TRANSPORT STRESSORS

J M MacCaluim*[†], S M Abeyesinghe[†‡], R P White[†] and C M Wathes[†]

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

[†] Silsoe Research Institute, Wrest Park, Silsoe, Bedfordshire MK45 4HS, UK

[‡] Contact for correspondence and requests for reprints: siobhan.abeyesinghe@bbsrc.ac.uk

Abstract

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Characterisation of the effect of transport on the welfare of fowl requires common currency methods that can compare the effects of diverse stressors using the same unit of measure. Aversion of broiler chickens (42 ± 1 days old) to vibrational and thermal stressors was investigated in a continuous free-choice procedure. Each choice-chamber had four compartments, connected via a central zone, offering a thermal stressor (T: 40°C, relative humidity 21%), a vibrational stressor (V: 2 Hz, 1 ms^{-2}), concurrent vibrational and thermal stressors (VT), or no applied stressors (N). In experiment 1, there were no significant effects of stressor on the latency to leave the compartments after initial introduction (n = 24). In experiment 2, 12 subjects were introduced individually to a chamber for 4 h during each of a control and two treatment sessions. The results indicated that chickens did not avoid vibration, but significantly avoided the thermal stressor overall (T and VT; P < 0.001). As no interactive effect of the stressors was observed, all avoidance of the combined stressors can be attributed to the effects of the thermal stressor alone. Further work is required to establish ways in which delayed stressors can be studied using behavioural methods before common currency methods can be practicable.

Keywords: *animal welfare, concurrent stressors, aversion, broiler chickens, vibration, temperature*

Introduction

The physical environment in which farm animals reside can comprise a number of stressors. Realistic characterisation of the effect of a complex environment, such as that encountered during transport, on a broiler chicken's welfare requires common currency methods, thereby allowing comparison of diverse stressors such as vibration (Randall *et al* 1997) and environmental temperature (Mitchell & Kettlewell 1998) with the same unit of measure. Scott's (1994) review indicates that vibration may interfere with thermoregulation through several mechanisms, possibly increasing the severity of stress. Energetic demand for maintenance of muscle tension, in order to prevent displacement of the major organs and maintain body posture, increases respiration-rate, metabolic heat production and thus the thermal load on the bird. Organ resonance during specific vibrations may increase body temperature directly through energy transfer and friction (Broderson 1972). Fatigue or difficulty in maintaining balance may encourage birds to squat, thereby restricting the surface area available for heat loss and increasing body contact with the vibrating surface. Vibration may also interfere with thermoregulatory panting and blood flow (Scott 1994).

Recently, Abeyesinghe *et al* (2001) developed a discrete-choice method as a potential common currency for measuring responses of broiler chickens to vibrational and thermal conditions. The method allows a range of dose-combinations to be tested to produce 'isoboles' (Berenbaum 1989), or contours of equal effect that characterise the interactions of a range of combinations of vibration and raised environmental temperature at different levels of magnitude and intensity. The investigation was initially limited, during the development of the method, to specific conditions (random vertical vibration at 2 Hz ± 10%, 1.0 ms^{-2} rms [root mean square] acceleration, and 40°C air temperature, 21% relative humidity [RH]) equivalent to those conditions experienced on transporters (Randall *et al* 1993; Mitchell & Kettlewell 1998). Birds were allowed to make a discrete choice and confined there for 60 min. Abeyesinghe *et al* (2001) found that although birds avoided the vibrational stressor — as seen in previous work (Randall *et al* 1997) — they did not avoid the thermal stressor and there was no combined effect of the stressors over and above the effect of vibration alone. Although not avoided, the thermal stressor evoked thermoregulatory panting and wing-droop within 30 min. One reason for not avoiding the thermal stressor may be that the delayed onset of heat stress interfered with the birds' abilities to associate it with entry to the treatment compartment. In a free-choice environment, birds could move away from the thermal stressor whilst experiencing it. However, the discrete-choice method with confinement required birds to learn, remember and predict what would happen *before* choosing a compartment on the basis of previous experience.

The objects of the current study were, first, to investigate further the responses of broiler chickens to the same vibrational and thermal stressors used by Abeyesinghe *et al* (2001) but in a continuous free-choice preference test, and second, to establish whether birds would choose to continue their exposure to the thermal stressor when free to leave. These were addressed in two experiments. The first examined initial acute responses to the stressors and birds' abilities to actively avoid both (Rutter & Duncan 1991; Abeyesinghe *et al* 2001). The second considered responses over a longer period of exposure. This work was regulated under the Animals (Scientific Procedures) Act 1986.

Experiment 1: Latency to terminate initial exposure to transport stressors

The aims of this experiment were twofold: first, to assess the initial acute responses of broiler chickens to specific vibrational and thermal stressors for comparison with longer-term responses; and second, to establish whether birds could actively avoid either or both stressors (Rutter & Duncan 1991).

Apparatus

Two choice-chambers (Figure 1) were used, each partitioned into four outer compartments linked via a central zone. This apparatus is described in detail by Abeyesinghe *et al* (2001). Clear polythene 'curtains', comprising lightweight strips that overlapped but allowed birds to walk through, were hung at all compartment junctions to maintain thermal conditions in each area. Each outer compartment offered water *ad libitum* but no food and was covered with a transparent Perspex lid to maintain the thermal environment and allow observation simultaneously. The chambers were lit by 60W tungsten strip-lights, producing approximate light intensities of 45 lux in the outer compartments and 20 lux in the central zone. A digital recording of the noise produced by the vibration rig was played continually through speakers situated under each stationary section. Each chamber supplied four different conditions in the outer compartments:

None (N): No applied stressors, ambient air temperature and humidity, no vibration.

Thermal (T): 40°C air temperature and approximately 21% RH, no vibration.

Vibration (V): Random vertical vibration at 2 Hz ± 10% and 1.0 ms^{-2} rms acceleration, ambient air temperature and humidity.

Vibration/Thermal (VT): Random vertical vibration at 2 Hz ± 10% and 1.0 ms^{-2} rms acceleration with 40°C air temperature and approximately 21% RH.

The design of the vibration rig meant that the chambers were arranged as mirror-images (Figure 1) and that treatment position could not be allocated randomly for each bird, potentially introducing a confounding factor. This was accounted for in the data analysis.

Animals and management

Six batches of 10 female Ross-strain broiler chickens, aged 37 days, were obtained from a commercial rearing farm at weekly intervals. On arrival, each batch was housed in a single room (12 m^2 floor), bedded with wood shavings and containing a suspended drinker. Pelleted commercial broiler feed was available *ad libitum*. Clear plastic polythene 'curtains' were fixed between the food and water stations, to accustom birds to moving through them prior to the experiment. A 12h:12h light:dark cycle was used, and a digital sound recording of the vibration rig was played continually to habituate birds to the noise. Birds were allowed three days to become accustomed to their surroundings, during which time four test birds from each batch were selected randomly and spray-marked for identification. Thus a total of 24 test birds were used and the remaining birds acted as companions. All birds had good walking ability (gait scores 0–1; Kestin *et al* 1992).

Procedures

Immediately prior to commencement of every experimental session, the drinkers were filled and the sound recording of the vibration rig was played. Individual test-birds were allocated randomly to one of the choice-chambers for the duration of the experiment and were trained to exit the outer compartments through the polythene curtains into the central zone. Training took place in a single session for each subject (no treatments applied) with a companion bird, selected randomly, to reduce isolation stress. After 20 min acclimatisation to the chamber, the test bird was placed directly within an outer compartment, oriented towards the doorway, while her companion was left in the central zone. If the test bird had not exited the compartment to join her companion within 10 min she was gently pushed through the curtains. She was allowed to spend approximately 1 min with her companion before being placed in a different outer compartment. The process was repeated until the test bird had exited each outer compartment within 5 min after placement, at which point she was considered trained. This training ensured that birds were able to terminate exposure to the treatment conditions at any time. Throughout the experiment, handling was minimised and was consistent between birds to reduce the effects of operator interference.

On the following day, food was removed one hour prior to testing to reduce interference between the heat increment of feeding and physiological effects of the thermal stressor (Mount 1979). Treatments (N, T, V and VT) were applied before the birds were introduced to the chambers; one bird in each chamber at a time. Each test bird underwent four trials. In each trial she was placed individually into one of the treatment compartments of the allocated chamber. The latency to exit the compartment into the central zone was recorded as an

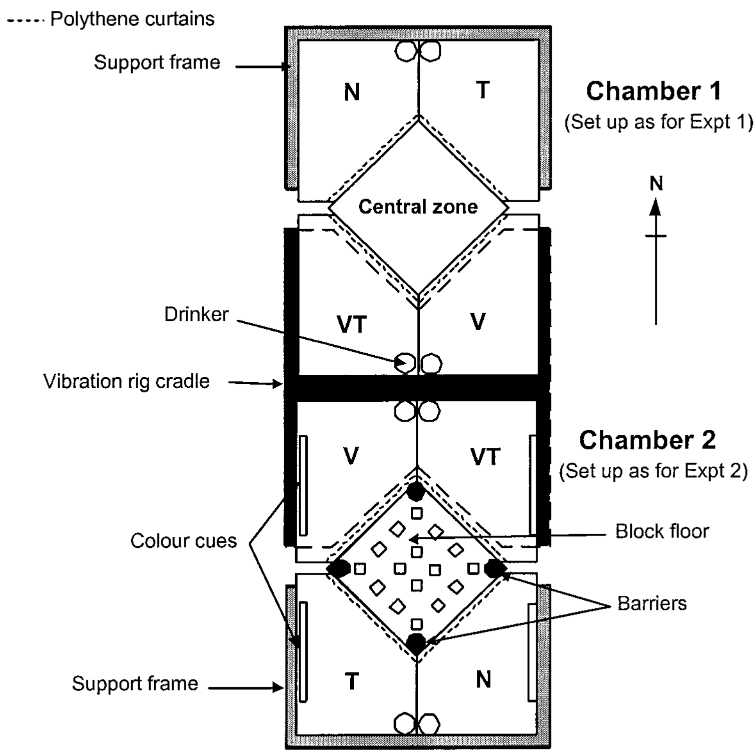

Figure 1 **Plan view of the choice-chambers, showing treatment positions (N = no applied stressors, T = thermal, V = vibration and VT = vibration/thermal stressors), and experimental set up for experiment 1 (chamber 1) and experiment 2 (chamber 2).**

indicator of aversion to the corresponding treatment. Each treatment was experienced by an individual in a random order. Birds were given 30 min to exit any treatment compartment, after which they were removed to ensure that they did not needlessly receive prolonged exposure. After exiting a treatment compartment, birds were returned to their home pen for a minimum of 30 min before introduction to the next test, to reduce interference between treatments and cumulative effects. When birds had been tested on all four treatments, the experiment was terminated and the birds returned to their home pen. All birds were either released from licensed procedures and returned to the food chain after satisfying inspection by a Named Veterinary Surgeon or killed using a Schedule 1 method. The mean (and standard deviation [SD]) temperature within treatment compartments N, T, V and VT was 19.6 (1.8), 20.8 (2.0), 19.7 (1.8) and 20.7 (2.1)°C, respectively, on the training day and 20.2 (2.2), 41.1 (1.6), 20.3 (2.4) and 41.1 (1.4)°C, respectively, on the treatment day.

Statistics

The sample size of 24 birds was chosen on statistical grounds and in consultation with the local Ethical Review Committee. The latencies (in seconds) to leave each treatment compartment were analysed statistically with a factorial analysis of variance, using Genstat®5 (Lawes Agricultural Trust 1998). The experimental factors were the vibrational and thermal stressors, each of which had two levels (present, not present), and their interaction. All analyses were blocked for batch, bird and compartment, the latter being the lowest level at which data were recorded. Visual inspection of the residual diagnostic plots of the analysis on the natural scale indicated that a transformation was necessary to meet the key assumptions of an analysis of variance, and inspection of similar diagnostic plots on the $\log_{10}$ scale confirmed that this was an appropriate transformation.

Results

The training data indicated no initial positional preferences. The analysis indicated no overall effects of vibration ($\log_{10}$-transformed mean latencies [s]: non-vibrating N & T; 2.02 vs vibrating V & VT; 1.92, SED = 0.11, df = 69, P = 0.368) or thermal stressor ($\log_{10}$-transformed mean latencies [s]: ambient N & V; 1.87 vs raised T & VT; 2.07, SED = 0.11, df = 69, P = 0.073) on latency to leave treatment compartments and no interaction (Table 1). Individual birds ranked the treatments differently: 11/24 birds left V faster than the other treatments, 6/24 left N fastest, 6/24 left VT fastest and 1/24 left T fastest. The majority of stays were of less than 3 min duration, and although there was a tendency for more birds to stay longer in the heated compartments, no bird stayed for the full 30 min in compartment T. Those birds which delayed leaving a compartment appeared to display normal investigatory and maintenance behaviour. It was therefore considered justifiable to proceed with a free-choice preference experiment.

Table 1 $\log_{10}$-transformed mean latencies (s) to leave each compartment.

N	T	V	VT	SED	*df*	*P*-value
1.89	2.15	1.85	1.99	0.11	69	0.605

Experiment 2: Continuous free-choice responses to transport stressors

The aims of this experiment were to assess the relative aversion of broiler chickens to vibrational and thermal stressors over time periods more relevant to transport and to determine whether birds would choose to continue exposure to these stressors when free to leave.

Animals and management

On six successive weeks, batches of eight female Ross-strain broiler chickens, aged 37 days, were obtained from a commercial farm. On arrival, each batch was housed as described for experiment 1. Two test birds from each batch were selected randomly and spray-marked for identification prior to the experiment. Thus a total of 12 test birds (mean ± SD weight = 1.7 ± 0.1 kg) with good walking ability (gait scores 0–1; Kestin *et al* 1992) were used, with the remaining birds acting as companions.

Apparatus and procedures

The apparatus used in experiment 1 was modified to discourage birds from remaining in the central zone by making it uncomfortable to lie there, but ensuring that it was not difficult to traverse. Several designs were tested in a pilot trial and the best selected. Uneven, rounded black wooden blocks (approximately 2 × 2 cm, with a sloped height of 2–3 cm) were attached in an evenly spaced radial pattern to false wooden floors covered with black rubber. These were placed in the central zone of each choice-chamber. To aid compartment discrimination, coloured cues (red, green, blue and yellow) were used around the entrances and inside each treatment compartment. For each individual bird, these cues were paired randomly with compartments for the duration of the experiment, but the compartment–cue combinations were balanced across birds to control for colour preferences.

The experimental procedure for each bird consisted of a training day, followed by a control day on which no treatments were applied, and two treatment days during which the stressors were applied to the chambers. The apparatus was set up as for experiment 1 with the addition of the false block floors, and the coloured cues were allocated to their corresponding treatment compartments (Figure 1). Individual test-birds were allocated randomly to one of the chambers for the duration of the experiment. Training proceeded initially as for experiment 1 (with no treatments applied) to ensure that birds learned to exit the compartments. However, when all four compartments had been exited, the test-bird and companion were left undisturbed in the chamber for a further 4 h to habituate, before being returned to the home pen, in order to reduce the possible interference of apparatus novelty on exploratory behaviour (Manteca & Deag 1994). On the following control day, food was removed 1 h before testing (and returned within 1 h afterwards). Test-birds were placed individually in the central zone of their chamber for a 4 h control session, with no treatments applied, to establish baseline positional preferences. The number and duration of compartment visits, along with scan-samples of postural behaviour at 5 min intervals, were recorded. A recorded visit commenced when the whole body of the bird was within the compartment and terminated when she had exited completely. This procedure was repeated on two consecutive days (4 h per day) with treatment conditions (N, T, V, VT) applied before birds were introduced. The number of treatment days was limited to two because the baseline exploratory behaviour (general activity and compartment visits) of birds was most consistent over the first four days of introduction to the choice-chambers (for 4 h per day) in a pilot trial. All subjects were monitored constantly during treatment exposure using overhead cameras, so that they could be removed immediately if necessary. The fate of birds was the same as for experiment 1. The mean (and SD) temperature within treatment compartments N, T, V and VT was 20.7 (1.4), 21.6 (1.8), 20.9 (1.4) and 21.5 (1.8)°C, respectively, on the control day and 23.1 (2.0), 40.8 (1.9), 23.3 (2.2) and 41.1 (1.8)°C, respectively, over the treatment days. The mean ambient temperature range in the experimental room was 20.6–23.7°C over the course of the experiment.

Statistics

The sample size was chosen on the same principles as for experiment 1. The collated data were analysed statistically with factorial, split plot design analyses of variance, using Genstat®5 (1998, Lawes Agricultural Trust). Visual inspections of the residual diagnostic plots of the analyses on the $\log_{10}$ scale and the square-root scale indicated that these transformations were appropriate, respectively, for the data for total time spent in, and for number of visits to, each compartment. The experimental and blocking factors were the same as for experiment 1 with the addition of 'treatment day' in the blocking structure. The factors in the treatment structure were arranged using Genstat notation, 'daytype/(split/(vibration × temperature))', nested to specify the strata at which effects should be assessed; 'daytype' described whether the data were from a control or a treatment day, 'split' nested within 'daytype' allowed discrimination between the two treatment days, and the interaction between vibration and temperature was nested within 'split' to specify that the treatment effects should be assessed according to the sequence of days rather than as independent and interchangeable, allowing for the effects of learning over the course of the experiment. Treatment effects were therefore assessed within day and, where appropriate,

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further analysis was carried out using the Student's *t*-test (Eason *et al* 1980). The postural behaviour data could not be analysed because of the limited number of scans in those compartments which were visited rarely.

Results

The statistical analysis indicated significant effects of the thermal stressor on both the total time spent in each compartment ($P < 0.001$; Figure 2a) and the number of visits ($P < 0.001$; Figure 2b) but no effect of vibration (Figures 3a,b) or interaction between stressors. To aid interpretation, the compartments are identified by the treatments eventually applied to them (note that no treatments were applied on the control day). The lack of interaction between the factors daytype, split, vibration and temperature indicated that no positional preferences influenced treatment responses. Figure 4 illustrates the frequency distribution of visit duration for each treatment on the control and treatment days. Over all birds, 65% of the 4 h control session was spent in the outer compartments. Out of a total of 67 visits, the majority were < 5 min, although longer visits were made equally to all outer compartments. On the first treatment day, when stressors were introduced to the outer compartments, the proportion of time spent in the treatment compartments decreased to 53%, while the total number of visits increased to 148. There was an increase in the number of short visits (< 5 min duration) to all treatment compartments and a dramatic reduction in the number of longer visits to the heated compartments (T and VT), the maximum stay being < 30 min for T and < 5 min for VT. On the second treatment day, the total time spent in the treatment compartments increased again (68%). While the total number of visits (140) was similar, visits to both T and VT decreased. The number of longer visits (> 5 min) to V on the second treatment day decreased, but was accompanied by an increase in shorter visits. The number of long visits to N increased. Postural behaviour displayed in a compartment was related to the amount of time spent there rather than the treatment applied. Thus behaviour in the N and V compartments was similar (ie mostly lying), but birds only walked in and out of the VT compartment without really staying. Although little time was spent in either the T or VT compartments, they were visited for a similar number of short periods (< 5 min) on all experimental days, suggesting that both environments were monitored continually (Nicol 1985) by at least some of the birds. However, most of these visits to the combined treatment (VT) were made by the same bird on both treatment days (48% and 82%, respectively), while the number of visitors decreased from six to three, suggesting that more birds were learning its position and avoiding it. Together with the fact that visits to VT of > 5 min duration did not occur, there is a suggestion that this treatment was the most aversive, although not significantly more so than T alone.

Discussion

The immediate response to the transport stressors tested in experiment 1 varied between individuals and no overall effects of treatment on latency to terminate exposure were indicated. This active avoidance method assumed that birds were able to leave compartments and that, if they did not, this indicated that they did not find the treatment aversive. The results suggest that the method was not sensitive enough to discriminate between responses to the stressors. Some of the variation in response may be explained by social motivation to return to the home pen, although this would have affected only the latter (of four) trials. Conversely, some birds may have been motivated to remain away from the home pen for

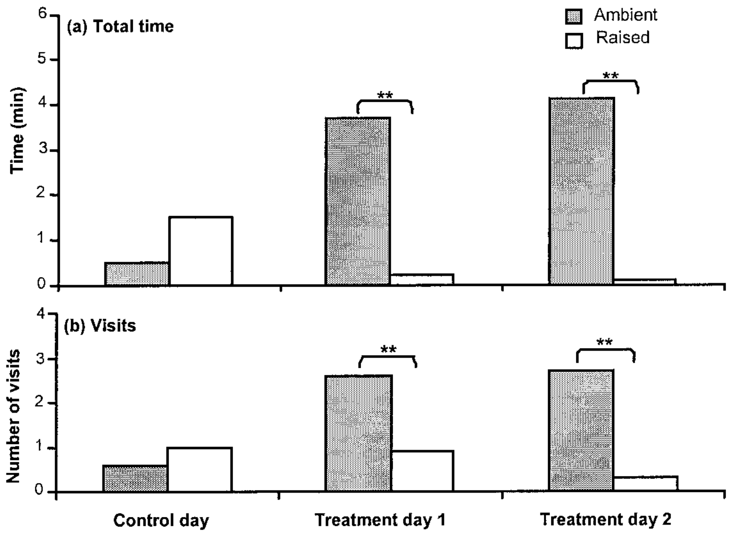

Figure 2 Experiment 2. (a) Back-transformed mean total time (min) per bird spent in, and (b) back-transformed mean number of visits per bird to, the ambient (N and V) and raised thermal (T and VT) compartments on the control (no stressors applied) and treatment days. Where appropriate, significant differences calculated using a Student's *t*-test are indicated (** = $P < 0.01$).

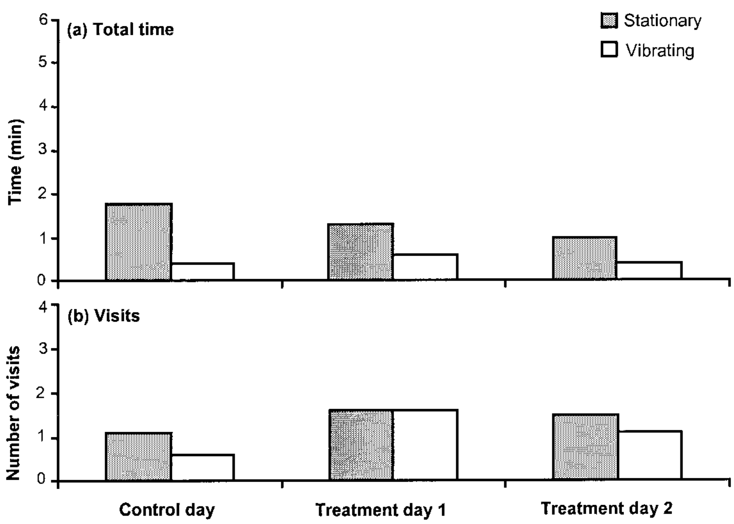

Figure 3 Experiment 2. (a) Back-transformed mean total time (min) per bird spent in, and (b) back-transformed mean number of visits per bird to, the stationary (N and T) and vibrating (V and VT) compartments on the control (no stressors applied) and treatment days. There were no significant differences between treatments ($P > 0.05$).

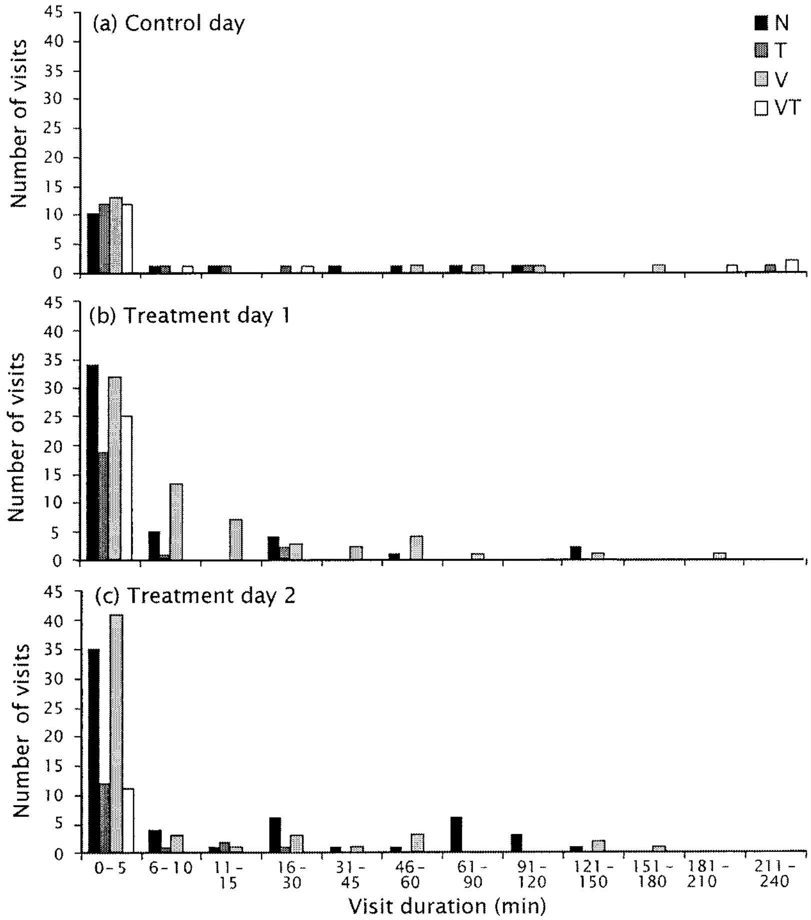

Figure 4 **Experiment 2. Frequency distributions (raw data) of visit durations (min) to treatment compartments N, T, V and VT on days (a) control (no stressors applied), (b) treatment 1, and (c) treatment 2.**

social reasons (Špinka *et al* 1998). While the trend was not significant ($P = 0.073$), approximately half of the birds avoided the vibration more quickly than the other treatments. Although no bird displayed difficulty in exiting through the curtains on the training day and there was no apparent 'freezing' (Bolles 1970), some may have found it difficult to negotiate the exit from a moving compartment to a stationary central zone. Conversely, there may simply have been variation in perception of vibration as aversive. Consistent with the findings of Abeyesinghe *et al* (2001), some birds did not avoid the thermal conditions quickly, but neither did they tend to stay long enough for signs of heat stress (Kettlewell 1989) to occur. It is possible that the heat was initially perceived as pleasant and birds subsequently exited the compartment only as they became too warm. This method may not have allowed the birds to become accustomed to the apparatus and responses may have been influenced by fear of the novel surroundings and isolation stress (Manteca & Deag 1994). These factors were addressed during training in experiment 2, which tested the longer-term, 'informed' response to the transport stressors and indicated a significant overall avoidance of the thermal stressor, but not of vibration or their interaction (ie V and T in combination).

Abeyesinghe *et al* (2001), using the same apparatus and treatment conditions, found that vibration was avoided ($P < 0.01$) but the thermal stressor was not and there was no interaction. However, this apparent contradiction may be explained by methodological differences, which highlights the need for care in method selection appropriate to the investigation and the type of factors that should be considered.

Abeyesinghe *et al* (2001) used a discrete-choice method in which 60 min confinement in the compartment of choice was titrated against motivation to feed. Subjects were fasted overnight and were therefore likely to have been more tolerant to heat than birds in the current study (Mount 1979). Further, the amount of food in the stomach may potentially affect the response to vibration by altering that organ's resonant frequency (Anon 1964). In the current study, birds were not fasted overnight because the freedom to roam would have been used for food-searching, potentially obscuring treatment responses and rendering the method less sensitive. Measures to reduce fearfulness were taken so that birds would be motivated to explore. Together with the environmental control conferred on the subject with unrestricted exit from compartments, this may have reduced the stress imposed by the treatments (Manteca & Deag 1994; Wiepkema & Koolhaas 1993) compared with Abeyesinghe *et al*'s previous study. Hughes (1976) showed that if hens are able to leave a less preferred environment, they are more likely to choose it than if they are confined to their choice for a fixed period. This supports the discrete-choice method as a more discriminatory technique. Confinement (Abeyesinghe *et al* 2001) may also have facilitated changes in perception of the conditions with time, ie vibration became more aversive with longer duration and in the absence of control of exposure by the subject. One current methodological difficulty was the presence of the same colour cues on the control and treatment days when the associated stressor environments were inconsistent. In further work, interference in learning the treatment–cue associations could be avoided by introducing the cues only when the stressors are applied. However, learning of the associations *per se* can be facilitated only by increasing their paired exposures, as was done by introducing a second treatment day, which may explain the clearer treatment responses subsequently seen.

The current finding that broilers avoid thermal conditions of 40°C (21% RH) supports the interpretation of previous results (Abeyesinghe *et al* 2001) as being attributable to an inability of the birds to associate delayed heat stress with entering the compartment, and/or to a relative preference for the heated compartments over the cold. The relatively few long visits to the thermal compartment (T) suggest that birds left this environment as they began to feel too warm. Given the results of earlier work (Randall *et al* 1997; Abeyesinghe *et al* 2001), the current finding that vibration was not avoided was surprising. There are three possible explanations: first, vibration was aversive but birds were either unable to exit the vibrating compartment or adopted an alternative strategy to mitigate its effects; second, vibration was initially perceived as aversive, but birds habituated to it with time; or third, vibration was not aversive relative to the other treatments. One possible alternative strategy to mitigate the effects of the vibration is to change posture. Birds find it difficult to maintain balance during low frequency vibrations and may squat or lie down to compensate (Randall *et al* 1995), probably altering the way the motion is perceived (Randall *et al* 1997). However, it is unlikely that this strategy was specifically adopted, as the proportion of lying behaviour in the vibration (V) and 'no stressor' (N) compartments was comparable. Nor did birds find it difficult to move between compartments or 'freeze' (Bolles 1970) during exposure, as evidenced by the large number of short visits to the vibration compartment (V) on the treatment days. Thus we can reject the first explanation. The previous findings of the aversiveness of short-term exposure (Randall *et al* 1997) are consistent with the second explanation over the third, particularly given the subjects' control of exposure and the training measures to reduce fearfulness which may have accelerated birds' habituation to vibration compared with birds in the discrete-choice study (Abeyesinghe *et al* 2001). However, their general behaviour indicated an avoidance of prolonged exposure. While the number of visits to the vibration compartment (V) remained consistent over the treatment days, they tended to become shorter, suggesting either some learned avoidance or a waning of the initial motivation to explore the novel environment, this being replaced by motivation to monitor or patrol a familiar environment (Nicol 1985).

In summary, the immediate response to vibrational and thermal stressors equivalent to those experienced during transport did not significantly differ from the response to 'no stressors'. However, the trend to terminate exposure to the vibration most quickly, together with findings from earlier studies (Rutter & Randall 1993; Randall *et al* 1997), suggests that vibration is initially perceived as aversive by broiler chickens at slaughter age and liveweight. Given the opportunity to control their exposure over longer periods, broiler chickens in the current study did not avoid vibration but, with experience, tended to limit their exposure to short visits. This suggests that perception of vibration as aversive may be influenced by subject control (Wiepkema & Koolhaas 1993). Control of exposure to the stressors resulted in behaviour consistent with behavioural thermoregulation and general avoidance of the thermal stressor. This finding is consistent with the hypothesis that birds in a previous study (Abeyesinghe *et al* 2001) were unable to associate entry to a compartment in which they were confined with the delayed effects of the thermal stressor. If this is the case, further work is required to establish ways in which delayed stressors can be studied using behavioural techniques before common currency methods can be practicable.

While it has shed some light on responses to vibration and thermal stressors equivalent to those experienced during poultry transport, the free-choice method is unsuitable as a common currency for these stressors because the exposure conditions, such as duration, cannot be standardised. An appropriate alternative is the discrete-choice method developed by Abeyesinghe *et al* (2001) which overcomes these limitations, allows greater discrimination between treatments and titrates responses against a standard motivation to feed.

Animal welfare implications

This study demonstrates that, when given control over their exposure, broiler chickens will avoid raised environmental temperatures equivalent to those which have been recorded on transporters in a manner consistent with behavioural thermoregulation. Together with previous work (Abeyesinghe *et al* 2001), the findings suggest that subject control (Wiepkema & Koolhaas 1993) plays an important role in the perception of vibration as aversive.

As with any laboratory experiment, there are important differences between conditions experienced on a transporter and the treatments provided experimentally, and these affect the appraisal with respect to commercial practice. First, the experimental birds were not fasted as occurs commercially, potentially decreasing their tolerance to heat; second, their training made them less fearful than naive birds; third, they were able to control their own exposure in a way impossible during transport; and finally, they were tested individually. Given these factors, it is possible that an experience which more closely represents the effects of these stressors during transport may be more aversive to birds. The current findings may be restricted to only those conditions tested: combinations of different vibrational and thermal conditions may be perceived differently by broilers. We know relatively little about the interactive effects of stressors on the welfare of broiler chickens during transport and yet they are generally experienced concurrently. Until more information on these effects is obtained, improvement in welfare during transport will be limited.

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References

Abeyesinghe S M, Wathes C M, Nicol C J and Randall J M 2001 The aversion of broiler chickens to concurrent vibrational and thermal stressors. *Applied Animal Behaviour Science 73*: 199-215

Anon 1964 *A study of the effects of anaesthesia, high oxygen and feeding upon resonant frequencies of visceral organs*. Technical report AMRL TDR-64-14. Aerospace Medical Research Laboratories, Wright-Patterson, AFB: Ohio, USA

Berenbaum M C 1989 What is synergy? *Pharmacological Reviews 41*: 93-141

Bolles R C 1970 Species-specific defence reactions and avoidance learning. *Psychological Review 77*: 32-48

Broderson A B 1972 Biothermal response of the rhesus monkey to mechanical vibration. *Annual Scientific Meeting of the Aerospace Medical Association, Florida, 8–11 May,* pp 41-42

Eason G, Coles C W and Gettinby G 1980 *Mathematics and Statistics for the Bio-Sciences*. Ellis Hoorwood Limited: Chichester, UK

Hughes B O 1976 Preference decisions of domestic hens for wire or litter floors. *Applied Animal Ethology 2*: 155-165

Kestin S C, Knowles T G, Tinch A E and Gregory N G 1992 Prevalence of leg weakness in broiler chickens and its relationship with genotype. *Veterinary Record 131*: 190-194

Kettlewell P J 1989 Physiological aspects of broiler transportation. *World's Poultry Science Journal 46*: 219-227

Lawes Agricultural Trust 1998 Genstat®5, Release 4.1 (Edn 4) for Windows. IACR: Rothamsted, UK

Manteca X and Deag J M 1994 Individual variation in response to stressors in farm animals: implications for experimenters. *Animal Welfare 3*: 213-218

Mitchell M A and Kettlewell P J 1998 Physiological stress and welfare of broiler chickens in transit: solutions not problems! *Poultry Science 77*: 1803-1814

Mount L E 1979 *Adaption to Thermal Environment.* Edward Arnold: London, UK

Nicol C J 1985 Non-exclusive spatial preference in the laying hen. *Applied Animal Behaviour Science 15*: 337-350

Randall J M, Duggan J A and Alami M A 1995 Influence of motion and vibration on animals. *Fleischwirtsch 72*: 158-160

Randall J M, Duggan J A, Alami M A and White R P 1997 Frequency weightings for the aversion of broiler chickens to horizontal and vertical vibration. *Journal of Agricultural Engineering Research 68*: 387-397

Randall J M, Streader W V and Meehan A M 1993 Vibration on poultry transporters. *British Poultry Science 34*: 635-642

Rutter S M and Duncan I J H 1991 Shuttle and one-way avoidance as measures of aversion in the domestic fowl. *Applied Animal Behaviour Science 30*: 117-124

Rutter S M and Randall J M 1993 Aversion of domestic fowl to whole-body vibratory motion. *Applied Animal Behaviour Science 37*: 69-73

Scott G B 1994 Effects of short-term whole body vibration on animals with particular reference to poultry. *World's Poultry Science Journal 50*: 25-38

Špinka M, Duncan I J H and Widowski T M 1998 Do domestic pigs prefer short-term confinement to medium-term confinement? *Applied Animal Behaviour Science 58*: 221-232

Wiepkema P R and Koolhaas J M 1993 Stress and animal welfare. *Animal Welfare 2*: 195-218